(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 601 837 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **93309832.9**

(51) Int. Cl.[6] : **G06K 11/06**

(22) Date of filing : **07.12.93**

(30) Priority : **07.12.92 JP 326545/92**

(43) Date of publication of application :
15.06.94 Bulletin 94/24

(84) Designated Contracting States :
DE GB

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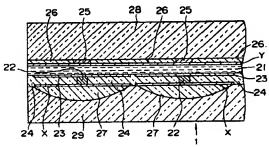
(54) Image input device-integrated type display device.

(57) There is provided an image input device-integrated type display device concurrently having an image display function, a document image input function, and a pen input function. A common electrode (Y) of the image input device-integrated type display unit (1) is formed on a glass plate (28). A segment electrode (X) is formed on a micro lens (27) of a glass plate (29). An island electrode (23) located at each pixel is connected to the segment electrode (X) via a photoconductor (22). Liquid crystals (21) are interposed between the common electrode (Y) and the island electrode (23). In an image input mode, light reflected on a document is applied to the photoconductor (22) to control a voltage applied to the liquid crystals (21). In a pen input mode, light from an input pen is applied to the photoconductor (22) to control a voltage applied to the liquid crystals (21). In an image display mode, a voltage applied to the liquid crystals (21) is controlled according to image data of each pixel. Thus brightness data of the document, position data of the input pen, and image data corresponding to a display signal are written into the image input device-integrated type display unit (1).

Fig.2



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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention reletes to en imege input device-integrated type displey device for use in an information apparatus such as a personal computer, a word processor, or an electronic notebook.

2. Description of the Prior Art

Information apparatuses such es a personel computer and e word processor ere demanded to be further compected end have e higher performance. In recent years, liquid crystel displey devices are increasingly used es e display unit for the information apparatuses in order to comply with the demand for compacting and reducing the weight of the apparatuses.

Besides, as e deta Input device for the abovementioned Information epperetuses, there are increasingly used an Image scanner (for taking out an object image to be input as an electric signal) and a tablet (for designeting an input position by means of a pen) other then a keyboard.

However, to constitute an epperetus heving en image display function, image input function, end pen input function, there hes been conventionally no wey except for the method of combining independent hardware units of a display device, an image scanner, end a tablet.

When such independent hardware units are combined to constitute an apparatus, there are performed only data communications between the hardware units by means of electric signals, where the hardwere units are not combined effectively and organically.

However, when independent herdwere units of a display device, an imege scanner, and a tablet ere merely combined with eech other to constitute en epperetus in a menner as described above, the resulting apperatus is inevitably dimensionally increased. Furthermore, even when the herdware units have therein common components, the components ere to be redundently used to result in significant wastefulness in terms of spece and cost.

Particularly, the aforementioned Image scanner is a bulky unit having a drive section, and therefore it is almost impossible to assemble an apparatus by integrating the image scanner with other hardwere units.

SUMMARY OF THE INVENTION

The object of the present invention is therefore to provide e compact imege input device-integrated type display device which concurrently hes en image display function, a document image Input function, end a pen input function.

In order to echieve the eforementioned object, there is provided en image input device-integrated type displey device comprising: a display unit having a plurality of transparent segment electrodes arranged in parallel with each other on a transparent substrate; a plurality of transparent common electrodes arranged in parallel with each other on another transparent substrate, said common electrodes being perpendicular to said segment electrodes, a photoconductor electrically connected to either the segment electrode or the common electrode and arranged in a pixel composed of an area of intersection between the segment electrode and the common electrode, a transperent islend electrode electrically connected to the photoconductor and erranged in between the segment electrode end the common electrode relevant to the pixel, liquid crystals interposed between the islend electrode and an electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor, and a light shielding film for shielding only light entering from the side of the electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor so thet the light does not reach the photoconductor; e displey illumination light source which irradietes display illumination light in displaying en imege on a pixel metrix composed of ereas of intersections between the plural segment electrodes and the plural common electrodes of the display unit; e document illuminetion light source which irradiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit; e control light source which irradiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals of the display unit; a display control circuit which outputs a display signal for displaying en image on the pixel matrix of the displey unit; en imege input control circuit which outputs en image input signel for copying en optical image of the document into the pixel metrix of the displey unit; en imege read control circuit which outputs an imege reed signal for reading image data written in the liquid crystals of each pixel constituting the pixel matrix of the display unit in the form of an electric signal; a segment electrode drive circuit which drives the segment electrode based on the display signal from the display control circuit, the Image input signal from the Image input control circuit, or the image read signel from the Imege read control circuit; e common electrode drive circuit which drives the common electrode based on the display signal from the display control circuit, the image input signal from the image input control circuit, or the image read signel from the image reed control circuit; en Image deta detection circuit which detects the Image data written in the pixel metrix of the display unit in the form of an

electric signal; and a control circuit which copies the optical image of the document into the pixel matrix by controlling the image input control circuit, the document illumination light source, and the control light source in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit, the image data detection circuit, and the control light source in an image read mode, and displays an image on the pixel matrix by controlling the display control circuit and the display illumination light source in an image display mode.

According to the above, at the pixel on which reflection light is incident from a white area of a document in the pixel matrix of the display unit set in the initial state under the control of a control circuit in the image input mode, the resistance of the photoconductor on which the reflection light strikes is made to have a low resistance, while a voltage is applied to the liquid crystals by the segment electrode drive circuit and the common electrode drive circuit based on the image input signal from the image input control circuit to thereby change the alignment state of the above-mentioned liquid crystals.

Thus, the optical image of the document is copied into the above-mentioned pixel matrix.

Furthermore, in the image read mode, the resistance of the photoconductor of the pixel on which the control light is incident under the control of the above-mentioned control circuit is made to have a low resistance, while a voltage based on the image read signal from the image read control circuit is applied to the segment electrode or the common electrode. Then the image data written in the above-mentioned pixel matrix are detected as an electric signal by the image data detection circuit.

Furthermore, in the image display mode, the resistance of the photoconductor of the pixel on which the display illumination light is incident under the control of the above-mentioned control circuit is made to have a low resistance, while a voltage based on the display signal from the display control circuit is applied to the aforementioned liquid crystals to thereby change the alignment state of the liquid crystals according to the above-mentioned display signal.

Thus, an image corresponding to the display signal from the above-mentioned display control circuit is written into the above-mentioned pixel matrix.

In an embodiment, phase transition type liquid crystals having a storage function are used as the liquid crystals.

According to the embodiment, in the aforementioned image input mode, the alignment state of the phase transition type liquid crystals is changed from the Grandjean state to the focalconic state and stored in the liquid crystals by the reflection light from the white area of the document to copy the optical image of the document into the above-mentioned pixel matrix. Furthermore, in the aforementioned image display mode, the alignment state of the phase transition type liquid crystals is changed into the above-mentioned Grandjean state or the focalconic state and stored in the liquid crystals according to the aforementioned display signal to write the image corresponding to the above-mentioned display signal into the above-mentioned pixel matrix.

Furthermore, the phase transition type liquid crystals exhibit a dielectric constant corresponding to the alignment state thereof. Therefore, in the aforementioned image read mode, a voltage signal which is, when a voltage is applied to one of the segment electrode and the common electrode, induced at the other electrode is detected by the aforementioned image data detection circuit to read the image data written in the pixel matrix as an electric signal.

In an embodiment, n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals having a storage function are used as the liquid crystals.

According to the embodiment, in the aforementioned image input mode, the alignment state of the n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals is changed from the Grandjean state to the focalconic state by the reflection light from the white area of the document. Furthermore, in the aforementioned image display mode, the alignment state of the n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals is changed to the Grandjean state or the focalconic state according to the above-mentioned display signal. Furthermore, in the aforementioned image read mode, a voltage signal which is, when a voltage is applied to one of the segment electrode and the common electrode, induced at the other electrode is detected by the aforementioned image data detection circuit.

There is provided an image input device-integrated type display device comprising: a display unit having a plurality of transparent segment electrodes arranged in parallel with each other on a transparent substrate; a plurality of transparent common electrodes arranged in parallel with each other on another transparent substrate, said common electrodes being perpendicular to said segment electrodes, a photoconductor electrically connected to either the segment electrode or the common electrode and arranged in a pixel composed of an area of intersection between the segment electrode and the common electrode, a transparent island electrode electrically connected to the photoconductor and arranged in between the segment electrode and the common electrode relevant to the pixel, liquid crystals interposed

between the island electrode and an electrode which is one of the segment electrode end the common electrode and is not electrically connected to the photoconductor, end e polerizer for controlling a polerization direction of only light entering from a side of the electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor, said light being to able to reach the photoconductor when the light passed through the polarizer; a display illumination light source which irradletes display illumination light in displaying en image on a pixel matrix composed of areas of intersections between the plural segment electrodes and the plural common electrodes of the dispiey unit; a document illumination light source which irradiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit; a control light source which lrradiates control light for optically controlling turning-on and turning-off of e voltege to be epplied to liquid crystals of the dispiey unit; a dlsplay control circuit which outputs a display signal for displaying an image on the pixel matrix of the display unit; an image input control circuit which outputs an image input signal for copying an optical imege of the document into the pixel matrix of the display unit; an image read control circuit which outputs an image reed signal for reeding image data written in the liquid crystels of each pixel constituting the pixel matrix of the display unit in the form of an electric signal; a segment electrode drive circuit which drives the segment electrode based on the display signal from the display control circuit, the image input signal from the image input control circuit, or the image read signal from the Image read control circuit; a common electrode drive circuit which drives the common electrode besed on the display signal from the display control circuit, the Image Input signal from the image input control circuit, or the image reed signal from the image reed control circuit; en Imege deta detection circuit which detects the image data written in the pixel matrix of the display unit in the form of en electric signal; and a control circuit which copies the optical image of the document into the pixel matrix by controlling the image input control circuit, the document illumination light source, and the control light source in an image Input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the Image read control circuit, the image data detection circuit, and the control light source in an image read mode, and displays an Image on the pixel metrix by controlling the display control circuit and the display illumination light source in en Image display mode.

According to the above device, the polarization direction of only the light which enters from the side of the electrode which is one of the segment electrode and the common electrode of the dispiey unit and is not electrically connected to the photoconductor Is controlled by the polarizer before the light reaches the photoconductor. Therefore, the presence or absence of the light incident on the above-mentioned photoconductor from the above-mentioned electrode which is not electrically connected to the photoconductor is set by the above-mentioned polarizer.

As e result, when the operations of the above-mentioned image input mode, image read mode, and image display mode are executed in the same manner as in the aforementioned first device, the resistence of the photoconductor is also set by the light entering into the photoconductor from the electrode which is not electrically connected to the photoconductor to set the on/off condition of the voltage applied to the liquid crystals.

In en embodiment, ferroelectric liquid crystals ere used as the liquid crystals.

According to the embodiment, in the aforementioned imege input mode, the alignment state of the ferroelectric liquid crystals is changed from the state where they are perpendicular to (or in parallel with) the polarization direction of the polarizer to the etate where they are in parallel with (or perpendicular to) the polarization direction of the polarizer by the reflection light from a white area of a document to copy the optical Image of the document into the aforementioned pixel metrix. Furthermore, in the aforementioned imege dispiey mode, the alignment state of the ferroelectric liquid crystals is changed to the perpendiculer state or to the parallel state according to the aforementioned display signal to write an image corresponding to the display signal into the above-mentioned pixel matrix. Furthermore, in the aforementioned image read mode, a specified voltage is applied to the above-mentioned ferroelectric liquid crystals to read the Image data written in the above-mentioned pixel matrix es an electric signal by means of the image data detection circuit.

In en embodiment, the image data detection circuit detects a quantity of electric charges charged according to the imege data at the island electrode of each pixel constituting the pixel matrix of the display unit, the control light source can irradiate light one by one on each electrode which is one of the segment electrode and the common electrode end is not electrically connected to the photoconductor, and the control circuit reads the Image data written in pixel matrix in the form of an electric signal by detecting a quantity of electric charges charged at the island electrode of the pixel relevant to the one segment electrode or common electrode which is selected by being irradiated by light of the control light source in the image read mode.

According to the embodiment, the island electrode which is in contact with the above-mentioned ferroelectric liquid crystals is charged with electric charges corresponding in quantity to the Image data. Therefore, in the aforementioned Image read mode,

a specified voltage is applied to the ferroelectric liquid crystals based on the image read signal from the image read control circuit to detect the quantity of electric charges charged at the island electrode at the pixel pertinent to the one segment electrode or common electrode which is selected by being subjected to irradiation of light from the control light source by the image data detection circuit.

Thus the image data written in the aforementioned pixel matrix are read as an electric signal.

In an embodiment, there is provided an input pen which has a light source and emits light from the light source outwardly through its tip end, and the control circuit controls the image input control circuit and the control light source in a pen input mode to allow an image input by means of the input pen to be written into the pixel matrix.

According to the embodiment, in the pen input mode, the pixel matrix of the display unit is set in the initial state under the control of the control circuit. Subsequently, the photoconductor of the pixel on which light directly from the light source of the input pen or reflection light is incident is made to have a low resistance, while a voltage based on the image input signal from the image input control circuit is applied to the liquid crystals to change the alignment state of the liquid crystals.

Thus, an image is written into the above-mentioned pixel matrix by the input pen.

In an embodiment, one of the two transparent substrates of the display unit is provided with a micro lens for condensing incident light thereto.

According to the embodiment, by virtue of the micro lens provided for one of the two transparent substrates of the aforementioned display unit, light which enters from the side of the transparent substrate at which the micro lens is not provided and is incident on the above-mentioned display unit is converged. Therefore, a sufficient quantity of light can be incident on the aforementioned photoconductor even when the quantity of light is reduced through reflection in, for example, the image input mode or the pen input mode.

Thus the brightness data of the document and the position data of the input pen are accurately written into the aforementioned pixel matrix.

In an embodiment, at least one of the two transparent substrates of the display unit is comprised of a plate-shaped optical fiber array where optical fibers each having a specified length are arranged two-dimensionally with axial directions of the optical fibers extended in a thickness direction of the optical fiber array.

According to the embodiment, light which is incident on the transparent substrate composed of a plate-shaped optical fiber array where optical fibers each having a specified length are arranged two-dimensionally with the axial directions of the optical fibers extended in the thickness direction of the optical fiber array travels through the above-mentioned optical fibers in the axial direction of the optical fibers. Thus the operation of each of the above-mentioned modes is executed without cross-talk betwaen pixels nor loss in quantity of light.

In a embodiment the display illumination light source, the document illumination light source, and the control light source are comprised of one plate-shaped light source, and a side portion of the plate-shaped light source is pivotally mounted to a side portion of the display unit.

According to the embodiment, the aforementioned display unit is illuminated by the plate-shaped light source provided pivotally at a side of the display unit from the front surface or the back surface of the display unit at need. Thus the display illumination light source, tha document illumination light source, and the control light source are concurrently provided by the above-mentionad one plate-shaped light source to axecute the operation of each of the aforemontioned modes.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given herelnbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wharein:

Fig. 1 is a schematic diagram of an Image Input davice-integrated type display device in accordance with an embodiment of the present invention;

Flg. 2 Is a sactional view of a part of an Image Input device-Integrated type display device as shown in Fig. 1;

Fig. 3 is a graph showing a voltage-transmittance characteristic of phase transition type liquid crystals;

Fig. 4 is a graph showing a voltage-dielectric constant characteristic of phase transition type liquid crystals;

Figs. 5(a), 5(b) and 5(c) are diagrams for explaining an operation in an image input moda of an image Input device-Integrated type display device employing phase transition type liquid crystals;

Fig. 6 is a longitudinal section view of an Input pen as shown in Flg. 1;

Fig. 7 is a diagram for explaining an operation in an Image read mode of an Image Input device-Integrated type display device employing phase transition type liquid crystals;

Fig. 8 is a diagram for explaining an operation in an image display mode of an image input device-Integrated type display device employing phase transition type liquid crystals;

Figs. 9(a), 9(b), 9(c) and 9(d) are diagrams for ex-

plaining a change of the state of current/electric field effect type liquid crystals;

Fig. 10 is e sectionel view of e part of an imege input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 11(a), 11(b), 11(c) end 11(d) are diegrams for expleining an operation in an image display mode of an imege input device-integrated type disply device employing ferroelectric liquid crystals;

Figs. 12(a), 12(b) end 12(c) are diagrams for expleining an operation in e pen input mode of en image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 13(a), 13(b) and 13(c) are diagrams for explaining an operation in a document image reed mode of en imege input device-integreted type disply device employing ferroelectric liquid crystals;

Figs. 14(a), 14(b) end 14(c) are diegrams for expleining an operation in a document image read mode of en image input devlce-integrated type display device employing ferroelectric liquid crystals;

Figs. 15 (a) and 15 (b) ere diegrams for explaining an operation in en image read mode of an imege input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 16(a) and 16(b) are diagrams for explaining an operation in an imege display mode of an imege input device-integreted type disply device employing ferroelectric liquid crystals;

Fig. 17 shows a perspective view of a part of a plate-sheped optical fiber erray; and

Figs. 18(a), 18(b) and 18(c) are diagrams showing a relation in posltion between an Imege Input device-Integreted type disply device of Fig. 1 end e back light.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following describes several embodiments of the present invention with reference to the ettached drawings.

Fig. 1 is a schemetic diegram of en image input device-integrated type display device of the present embodiment.

The present image input device-integrated type display device has several operation modes having the functions as follows. The operation modes are image display mode for writing en imege into liquid crystals by means of an electric signel, a pen input mode for writing an image into liquid crystals by means of an input pen, an image input mode for directly copying an optical imege of e document into liquid crystels, end an image read mode for reading an image written in liquid crystals in the pen input mode and the image input mode in the form of an electric signal.

Referring to Fig. 1, the above-mentioned imege input device-integrated type disply device comprises basically en image input device-integrated type display unit 1 composed of segment electrodes X_1, X_2, ... X_m (each of the segment electrodes indiscriminetely referred to as X hereinafter) arranged in parallel in m columns and common electrodes Y_1, Y_2, ... Y_n (each of the common electrode indiscriminately referred to es Y hereinafter) arranged in parallel in n rows perpendiculer to the segment electrode X and serving as an image input device, and a variety of peripheral circuits provided for the imege input device-integrated displey unit 1.

Each common electrode Y is connected to a common electrode drive circuit 2 end a common electrode selection circuit 4. On the other hend, each segment electrode X is connected to a segment electrode drive circuit 3.

A display control circuit 6 generates a display signal for displaying an image on liquid crystals interposed between the segment electrode X and the common electrode Y of the imege input device-integrated display unit 1 by applying a voltage to the liquid crystals in the aforementioned image display mode. Furthermore, the dispiey control circuit 6 generates an initialization signel for putting the abovementioned liquid crystals into the initiel state in the pen input mode or the image input mode.

An image deta detection control circuit 7 generates en image reed signel for reading en image written in the liquid crystals by applying a voltage to the segment electrode X of the imege input device-integrated dispiey unit 1 in the aforementioned image reed mode.

An imege Input control circuit 8 generates an Image input signal for writing en optical imege of a document or e pen input image by applying a voltage to the liquid crystals by means of the segment electrode X and the common electrode Y of the Image input device-integrated dispiey unit 1 in the aforementioned imege input mode or the pen input mode.

A switching circuit 5 switches between the display signal or the initielization signel from the aforementioned dispiey control circuit 6, the Image read signel from the image data detection control circuit 7, end the Imege Input signal from the image input control circuit 8 to output the selected signal switchingly to the common electrode drive circuit 2 end the segment electrode drive circuit 3.

An imege data detection circuit 9 detects a voltage induced at the common electrode Y of the Image input device-integrated display unit 1 es imege deta in the image read mode.

An input pen 10 designates en input pixel when writing an image into the image input device-integrated display unit 1 in the pen input mode.

A back light 11 is controlled to ba turned on and off and controlled of its position with respact to tha imaga input device-intagrated displey unit 1 by a back light control circuit 12. The back light 11 irradiates light at naed from the front or back side of the image input device-integrated display unit 1.

A control circuit 13 controls the display control circuit 6, image deta detection control circuit 7, imege input control circuit 8, imege deta detection circuit 9, end back light control circuit 12 to axecute tha operation in each of the imaga display moda, pan input moda, image input mode, and image read mode.

In more detail, the image input device-integrated display unit 1 constitutes the aforementioned display unit, and the image data datection control circuit 7 constitutes the image read control circuit.

Tha image input device-integrated typa display device having tha above-mentioned construction operates in tha following manner in each of the operation modes under the control of the control circuit 13.

In tha aforemantioned imaga display moda, first tha switching circuit 5 is switched to the displey control circuit 6 to transmit the aforementioned displey signal generated by the display control circuit 6 to tha common electrode drive circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then the common electrode drive circuit 2 and the segment electrode drive circuit 3 scans the common electrode Y and the segment electrode X of the image input device-integratad display unit 1 to apply a voltaga corresponding to tha display signal to the liquid crystals of each pixal of a pixel matrix composed of tha erees of intersections between the segment alactrodes and tha common electrodes. At tha same time, tha back light 11 is lit to display an imaga on tha matrix of $n \times m$ pixels. In tha abova time, the polarities of the voltages applied to the segment electrode X and the common electrode Y are inverted every line or every frame in the same manner as in the general direct multiplexing matrix liquid crystal display device.

In the aforementioned image input mode, first the switching circuit 5 is switched to the display control circuit 6 sida to transmit the initialization signal ganarated by the display control circuit 6 to the common alectroda drive circuit 2 and tha segmant alactroda drive circuit 3 vie the switching circuit 5. Than the elignment state of the liquid crystals of tha antire pixel matrix of the imaga input device-integrated display unit 1 is set in an initial state as described hereinafter.

Subsequently, the switching circuit 5 is switched to the image input control circuit 8 side to transmit the aforementionad image input signal generated by the image input control circuit 8 to the common electrode drive circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then a voltaga for writing tha optical imaga of e document is eppliad between the segmant alectrode X and the common alectroda Y.

In the aforementioned pen input mode, first tha switching circuit 5 is switched to the display control circuit 6 side to set tha alignment state of tha liquid crystals of the aforementioned pixel matrix in tha initial state. Subsaquently, tha switching circuit 5 is switched to the image input control circuit 8 side to transmit the eforementioned imege input signal generated by the imege input control circuit 8 to tha common alectroda driva circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then a voltage for writing tha position desiqnated by tha input pan 10 is applied to tha segmant electrodas and tha common alactrodes.

It is noted that the back light 11, which is not necessary in tha above case, is unlighted.

In the aforementioned image read mode, tha switching circuit 5 is switched to tha imege data detection control circuit 7 side to transmit tha imaga read signal genarated by the imaga data detection control circuit 7 to the segment electrode drive circuit 3 via the switching circuit 5. Than e voltage for reading an imaga is successively applied to each segmant electrode X by the segment electrode drive circuit 3.

On the other hand, each common elactrode Y is succassively selacted by the common electroda selection circuit 4, and an imaga signal induced at the selected common electroda Y is detected by tha imaga data datection circuit 9 to ba transmitted to the control circuit 13.

It is noted that the back light 11 irradiates light onto tha image input device-integrated display unit 1 from behind the unit 1.

Then the following describes in detail the image input davice-integrated display unit 1 which is an important component of tha present invention.

Fig. 2 is a sectional viaw showing a part of an imaga input davice-integrated type display unit 1 of the present embodiment taken along the common elactrode Y. Referring to Fig. 2, thera ara provided liquid crystals 21, photoconductors 22, and island electrodes 23. Thera are further providad segmant electrodes X and common elactrodas Y.

The above-mantionad sagmant alectrode X, common elactrode Y, and island electrode 23 are transparant alectrodas mada of indium tin oxide (ITO). In Fig. 2, tha segment electrodes X extend in a direction perpendicular to the plane of tha papar on which Fig. 2 is illustrated, and transverse cross sections of two segment electrodes X exist. On the other hand, the common alactrode Y extends in a direction parallel with the plane of the paper on which Fig. 2 is illustrated, and the longitudinal section of ona common electrode Y axists. Hance an area of intersection between the segment electrode X and tha common elactroda Y constitutes a pixel.

The aforementionad island electrode 23 is pro-

vided for each pixel, and each island electrode 23 is surrounded by a transparent insulator 24. Therefore, island electrodes 23 are electrically isolated from each other.

The aforementioned photoconductor 22 has an infinitesimal section area and is arranged in an approximate center position of each pixel. The segment electrode X and the island electrode 23 constituting each pixel are electrically connected to each other by way of the photoconductor 22. The photoconductors 22 are surrounded by the above-mentioned transparent insulator 24.

The photoconductor 22 is a material of which resistivity changes when it receives light. The photoconductor 22 is made of cadmium sulfide (CdS), cadmium telluride (CdTe), selenium (Se), zinc sulfide (ZnS), bismuth silicate crystal (BSO), amorphous silicon, organic photoconductor, or the like.

The transparent insulator 24 for electrically isolating the photoconductors 22 is made of silicon oxide (SiO_2), titanium oxide (TiO_2), or an organic material such as resist.

There is formed a light-shielding film 25 on the common electrode Y above the photoconductor 22. The light-shielding film 25 prevents incident light through a glass plate 28 from directly entering into the photoconductor 22. The light-shielding film 25 is composed of a thin film made of aluminum (Al), tungsten (W), tungsten silicide (WSi), or the like.

A transparent insulator 26 is made of silicon oxide (SiO_2), titanium oxide (TiO_2), an organic material such as resist, or rubber for the purpose to flatten the unevenness generated due to the light-shielding film 25.

Each of glass plates 28 and 29 function as a transparent substrate for encapsulating the aforementioned liquid crystals 21. Therefore, the glass plates 28 and 29 may be each made of a transparent plastic plate or a transparent ceramic plate.

In a position corresponding to each pixel on the interior surface of the glass plate 29 is formed a micro lens 27 protruding into the glass plate 29. The micro lens 27 has a function of condensing incident illumination light transmitted through the glass plate 28 and light reflected on a document, and the convergent point of the lens is located at around the exterior surface of the glass plate 29. The micro lens 27 is formed by making the glass plate 29 have a refractive index distribution or a curved surface, or by bundling optical fibers.

The aforementioned liquid crystals 21 are composed of liquid crystals which have a storage function and exhibits a change of dielectric constant thereof between a state where they display a black color and a state where they display a white color (referred to merely as "between black and white colors" hereinafter). The following describes an example employing phase transition type liquid crystals.

The phase transition type liquid crystals are composed of p-type cholesteric liquid crystals or liquid crystals formed by mixing p-type cholesteric liquid crystals with p-type nematic liquid crystals. Fig. 3 shows a voltage-transmittance characteristic of liquid crystals of the above-mentioned type.

Referring to Fig. 3, in an initial state where an applied voltage is lower than "Vth1", the liquid crystals are in the Grandjean state where the helical axes of the cholesteric liquid crystal molecules are aligned in a direction perpendicular to the electrode surface. In the Grandjean state, incident light perpendicular to the electrode surface is transmitted. When the applied voltage is gradually increased above "Vth1", the liquid crystals are put into the focalconic state where the directions of the helical axes which have been aligned in a direction perpendicular to the electrode surface are disordered to be directed in irregular directions. In the focalconic state, the refractive index is disordered to diffuse light, with which the liquid crystals become turbid whitely.

Then, according as the applied voltage is further increased, the helical axis pitch of the cholesteric liquid crystals increases. When the applied voltage exceeds a threshold voltage "Vth2", the liquid crystals are transformed into nematic liquid crystals where liquid crystal molecules are aligned in the direction of an electric field (i.e., a homeotropic orientation). In the homeotropic orientation, the liquid crystals are optically transparent.

It is noted that the voltage to be applied to the liquid crystals may be an AC voltage or a DC voltage.

In order to store the state of the liquid crystals as described above, the applied voltage to the liquid crystals is required to be "0". For instance, when the applied voltage is made to be "0" in the focalconic state, the focalconic state is maintained and stored. When the applied voltage is abruptly made to be "0" in the homeotropic orientation state, the liquid crystals are transformed into the Grandjean state, and the Grandjean state is maintained and stored to maintain the transparent state.

The above-mentioned liquid crystals are dielectric substance, and therefore the liquid crystals exhibit a dielectric polarization when an electric field is applied to the liquid crystals. Fig. 4 shows a change of dielectric constant between black and white colors corresponding to the state of the liquid crystals as shown in Fig. 3. Referring to Fig. 4, the dielectric constant increases while the liquid crystals are transformed from the Grandjean state via the focalconic state to the homeotropic orientation.

As liquid crystals which have the above-mentioned storage function and exhibit a change of dielectric constant between black and white colors, there are liquid crystals of a type which is to be subjected to a write operation by a current effect and an erasing operation by an electric field effect (the liquid crystals referred to as the "current/electric field ef-

fect type liquid crystals" hereinafter) such as n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, and smectic-A liquid crystals, and ferroelectric liquid crystals other than the above-mentioned phase transition type liquid crystals.

First Embodiment

Then the following describes the principle of operation of the image input device-integrated display unit 1 employing phase transition type liquid crystals as the liquid crystals 21 in regard to each of the aforementioned modes with reference to Figs. 5 through 8.

(1) Image input mode (in which the optical image of a document is optically written directly into the image input device-integrated display unit)

In a first step, the liquid crystals 21 are entirely put into a transparent state (i.e., into the aforementioned Grandjean state) (Fig. 5 (a)).

Control light is irradiated on the entire surface of the liquid crystals by the back light 11 from the side of the glass plate 29, and a voltage which is not lower than "Vth2" is applied across segment electrodes X and common electrodes Y from a power source 30 based on the aforementioned initialization signal from the display control circuit 6. In the above time, a voltage may be successively applied to each segment electrode X and each common electrode Y, or simultaneously applied to all the segment electrodes X and all the common electrodes Y.

Thus the photoconductor 22 is made to have a low resistance by the incident light from the side of the glass plate 29, with which the segment electrode X and the island electrode 23 connected to the photoconductor 22 are made to have an approximately equal potential. Consequently, a voltage approximately equal to the voltage "Vth2" supplied from the power source 30 (the voltage is slightly reduced by a voltage drop due to the photoconductor 22) is applied to the liquid crystals 21, with which the liquid crystals 21 are put into the homeotropic orientation.

Subsequently, when the voltage applied across the above-mentioned segment electrode X and the common electrode Y is abruptly made to be "0", the liquid crystals 21 are restored from the homeotropic orientation to the Grandjean state to maintain a transparent state. Then the control light from the side of the glass plate 29 is turned off.

Thus the liquid crystals 21 are entirely put into a transparent state to put the liquid crystals 21 into the initial state before image input.

In a second step, reflection light from a document 31 is copied into the liquid crystals 21 (refer to Figs. 5 (b) and 5 (c)).

The document 31 is placed under the glass plate 29 with the document substantially closely fit to the glass plate 29. Based on an image input signal from the image input control circuit 8, a voltage which is not lower than "Vth1" and lower than "Vth2" is applied across each segment electrode X and each common electrode Y from the power source 30. In the above time, a voltage may be successively applied to each segment electrode X and each common electrode Y, or simultaneously applied to all the segment electrodes X and all the common electrodes Y.

Then document illumination light is irradiated on the entire surface of the glass plate 28 by the back light 11 from the glass plate 28 side. Since the liquid crystals 21 have been already made to be transparent in the aforementioned first step, the document illumination light incident on the glass plate 28 reaches the micro lens 27 by way of the transparent insulator 26, common electrode Y, liquid crystals 21, island electrode 23, transparent insulator 24, and segment electrode X except for the area of the light-shielding film 25. Then the light is converged on the document 31 by the micro lens 27.

In the case where the convergence light strikes on a white area of the document 31, the light is reflected on the white area as shown in Fig. 5 (b). A part of the reflection light is transmitted through the segment electrode X to be incident on the photoconductor 22.

Then the photoconductor 22 on which the light strikes is made to have a low resistance, with which the segment electrode X and the island electrode 23 connected to the photoconductor 22 are made to have an approximately equal potential.

Consequently, a voltage approximately equal to the voltage which is not lower than "Vth1" and lower than "Vth2" applied across the segment electrode X and the common electrode Y is applied across the island electrode 23 and the common electrode Y. Therefore, the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which the light strikes are transformed from the initial Grandjean state into the focalconic state to be turbid whitely.

In other words, the white area of the document 31 is invertedly written into the liquid crystals 21 as a black area.

In contrast to the above, in the case where the convergence light strikes on a black area of the document 31, no light is reflected on the black area as shown in Fig. 5 (c), and therefore no light strikes on the photoconductor 22. Therefore, the photoconductor 22 on which no light strikes remains having a high resistance.

In the above case, by setting the resistance of the photoconductor 22 in condition where no light strikes on it (the resistance in this condition referred to as the "dark resistance" hereinafter) at a value sufficiently higher than the resistance of the liquid crys-

tals 21, almost no voltage is applied across the island electrode 23 and the common electrode Y because of a significant voltage drop across the segment electrode X and the island electrode 23.

Consequently, a voltage which is lower than "Vth1" is applied across the island electrode 23 and the common electrode Y. Therefore, the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which no light strikes maintain the initial Grandjean state to be transparent.

In other words, the black area of the document 31 is invertedly written into the liquid crystals 21 as a white area.

Thus in the image input mode, a negative image of the document 31 is written into the matrix of $n \times m$ pixels of the image input device-integrated display unit 1.

In order to store the optical image of the document 31 which has thus written in the pixel matrix of the image input device-integrated display unit 1 into the liquid crystals 21, the voltage applied across the segment electrode X and the common electrode Y from the power source 30 is required to be "0", and the document illumination light is required to be removed.

The image input mode is described above by exemplifying the case where the optical image of the document 31 is stored into the liquid crystals 21 by means of the reflection light from the document 31. However, the image input device-integrated display unit 1 of the present embodiment can store the optical image of the document 31 into the liquid crystals 21 by means of a transmission light from a transparent document.

The following describes the image input mode using a transparent document.

In order to write the optical image of the transparent document into the liquid crystals 21, the transparent document is placed under the glass plate 29, and document illumination light is radiated by the back light 11 from under the transparent document. In the above case, either a negative image or a positive image of the document can be written into the aforementioned pixel matrix.

In the case where the negative image is written, a voltage which is not lower than "Vth1" and lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30 with the initial state set in the Grandjean state in the same manner as in the aforementioned case where the optical image of the document 31 is stored into the liquid crystals 21 by means of the reflected light from the document 31.

A part of light transmitted through a transparent portion of the transparent document is transmitted through the segment electrode X to strike on the photoconductor 22. Consequently, a voltage approximately equal to the voltage which is not lower than "Vth1" and lower than "Vth2" and is applied across the segment electrode X and the common electrode Y is applied to the liquid crystals 21, with which the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which the light strikes are transformed from the initial Grandjean state to the focalconic state to be turbid whitely.

In other words, the transparent area of the above-mentioned transparent document is invertedly written and stored into the liquid crystals 21 as a black area.

In contrast to the above, the photoconductor 22 which is shielded from the document illumination light by an opaque portion of the document remains having a high resistance. Consequently, a voltage which is lower than "Vth1" is applied to the liquid crystals 21, while the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which no light strikes maintain the initial Grandjean state to be transparent.

In other words, the opaque area of the above-mentioned transparent document is invertedly written and stored into the liquid crystals 21 as a white area.

Thus the negative image of the above-mentioned transparent document is written into the pixel matrix of the image input device-integrated display unit 1.

Then the following describes the case where the aforementioned positive image is written.

In order to write the positive image, a voltage which is not lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30 with the initial state set in the focalconic state (where the liquid crystals are turbid whitely).

Then a part of light transmitted through a transparent portion of the above-mentioned transparent document is transmitted through the segment electrode X to strike on the photoconductor 22. Consequently, a voltage approximately equal to the voltage which is not lower than "Vth2" and is applied across the segment electrode X and the common electrode Y is applied to the liquid crystals 21, with which the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which the light strikes are transformed from the initial focalconic state to the homeotropic orientation to be transparent.

In other words, the transparent area of the above-mentioned transparent document is written and stored into the liquid crystals 21 as a white area.

In contrast to the above, the photoconductor 22 which is shielded from the document illumination light by an opaque portion of the above-mentioned transparent document remains having a high resistance. Consequently, a voltage which is lower than the "Vth2" is applied to the liquid crystals 21. In the above case, by setting the dark resistance of the photocon-

ductor 22 at a valua such that the voltaga across the island alactroda 23 and the common electrode Y is not lower than "Vth1" and lower than "Vth2", a voltage which is not lowar than "Vth1" and lower than "Vth2" and is appliad to tha liquid crystals 21.

Tharefore, the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 which is shielded from the document illumination light maintain the initial focalconic state to ba turbid whitely.

In othar words, tha opaqua area of the abovamantionad transparent documant is written and storad into tha liquid crystals 21 as a black area.

Thus tha positiva imaga of tha above-mantioned transparent document is written into tha pixel matrix of tha imaga input davice-integratad display unit 1.

It is noted that tha light-shialding film 25 is not necessary when tha optical imaga of the abovementioned transparent documant is writtan into tha pixel matrix of tha image input device-integrated display unit 1.

Tha control light and the document illumination light in tha case where the optical imaga of tha document 31 is storad into the liquid crystals 21 by maans of tha reflection light from tha document 31 ara obtainad by moving the back light 11 on tha sida of the glass plata 28 or on the side of tha glass plata 29 of the imaga input davice-integrated display unit 1 as described in datail hereinafter.

(2) Pen input moda (in which an imaga is writtan into tha imaga input davice-integratad display unit by means of an input pen which emits light)

Fig. 6 shows a sectional vlaw of tha abovamantioned input pan 10. The input pan 10 has a built-in light source 41 composed of an LED (LIght-Emitting Diode), a semiconductor laser, an EL (Elactro Luminescence), or tha lika. Light emitted from the light source 41 is conducted to the tip of tha pen by way of a photoconducting path 42 composed of a plastic fibar or the like. The photoconducting path 42 is covered with a sleava 43, where tha tip of the sleava 43 is slightly protruding from tha tip of the photoconducting path 42.

An axially inward and of tha sleava 43 is fittad to an end of a spring 44. Tha other and of tha spring 44 is put in contact with a pan touch switch 45. With the abova-mentioned arrangement, whan the tip of the input pan 10 (i.e., the tip of the sleeve 43) is pressed, tha pan touch switch 45 is turned on to ba abla to discriminate whether tha operator is in an input operation.

A pan control circuit 46 makes tha light source 41 amit light by transmitting a light source control signal upon reception of an "on signal" (referred to as a "touch signal" harelnaftar) from the pen touch switch 45. It is noted that a power is suppliad from a small-size battery 47 to tha pan control circuit 46.

A casing 48 has a cylindrical configuration to sarva as an axterior wall which supports tha sleave 43 with its conical and portion and fixes tha above-mantioned light source 41, spring 44, pen touch switch 45, pen control circuit 46, and amall-size battary 47.

Tha pan input moda operation is executad in the same manner as in the case where the optical image in the white area of the document 31 is written into the liquid crystals. Tha followlng describes tha operation with rafarence to Fig. 5 (b).

After tha liquid crystals 21 of tha Imaga input device-integratad display unit 1 ara put into an initial state (Grandjean stata: transparant state), a voltage which is not lowar than "Vth1" and lower than "Vth2" is applied across the segmant alectroda X and the common electroda Y from tha powar sourca 30 based on tha imaga input signal from tha imaga input control circuit 8. On tha othar hand, a white sheat is placad under tha glass plate 29 with tha sheet substantially closaly fit to tha glass plata 29.

Now tha tip of tha input pan 10 is placed in an area on the glass plate 28 corresponding to the write pixels of the pixel matrix of tha image input device-integrated display unit 1, and than tha casing 48 of tha input pan 10 is pressed against the glass plate 28. By so doing, the pan touch switch 45 is turnad on to maka the light source 41 emit light.

Than, tha light conducted from the light source 41 to tha photoconducting path 42 is amittad from the tip of tha slaava 43 to anter into tha Imaga Input device-integrated display unit 1. Tha light which is converged by the micro lans 27 and transmitted through tha imaga input device-integratad display unit 1 is reflected on the white sheet to strike on tha photoconductor 22. Consaquantly, tha resistance of tha photoconductor 22 is raducad, and a voltage which is not lowar than "Vth1" and lower than "Vth2" is appliad to tha liquid crystals 21 constituting the relavant pixel to theraby transform tha liquid crystals 21 into tha focalconic state (whara tha liquid crystals ara turbid whitely).

Subsaquently, when tha input pan 10 is moved out of the relavant pixal area or tha input pen 10 is put apart from the imaga input davice-integrated display unit 1 to turn off tha pen touch switch 45, no light is incident on tha ralevant pixal to make tha resistance of the photoconductor 22 be the dark resistance. Consequently, a great voltage drop takes place at the photoconductor 22 with which tha voltage applied to tha liquid crystals 21 is mada to ba "0".

Thus tha liquid crystals 21 in the ralavant pixel area put in tha focalconic state by tha pan input maintain tha focalconic state. In othar words, dark data are writtan into tha liquid crystals 21 in the relavant pixel area by tha pen input.

By drawing a characlar or a figure on tha Image input davice-Intagrated display unit 1 by means of the Input pan 10 in tha above-mentionad manner, the

character or figure is written into the pixel matrix.

In the above case, by time-sharingly processing the above-mentioned pen input mode and the image read mode described in detail hereinafter, the coordinates of the pixel currently designated by the input pen 10 can be detected.

In the above-mentioned pen input mode, a part of image already written in the pixel matrix of the image input device-integrated display unit 1 can be erased.

In order to do so, a voltage which is not lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30. By tracing the line which is desired to be erased by means of the input pen 10, the liquid crystals 21 in the relevent pixel area in which the dark data pertinent to the objective line to be erased are written is transformed from the focalconic state to the homeotropic orientation.

Thus the derk data written in the liquid crystals 21 in the relevant pixel area are rewritten into light data to erase the objective line to be erased.

(3) Image read mode (in which an image written in the image input device-integrated display unit is read as an electric signal)

Fig. 7 is a schematic sectional view of the above-mentioned image input device-integrated display unit 1, where elements irrelevent to the image read mode are eliminated.

The liquid crystals 21 of the pixels constituting the pixel metrix of the image input device-integrated display unit 1 are in the Grandjean state, focalconic state, or a state between them according to the brightness data written in the image input mode or the pen input mode.

Control light is irradiated by the back light 11 from the side of the glass plate 29. Then the incident light strikes on the photoconductor 22 to make the photoconductor 22 have e low resistance.

In the above-mentioned condition, each segment electrode X is successively scanned by successively applying pulses of a voltage which is not higher than "Vth1" to the segment electrodes ..., X_a, X_b, X_c, X_d, ... by means of the segment electrode drive circuit 3 based on image read data from the image data detection control circuit 7. Since the photoconductor 22 has a low resistance in the above case, island electrodes ... 23_a, 23_b, 23_c, 23_d, connected to the segment electrode X via each photoconductor 22 are scanned by the pulses of the voltage which is not higher then "Vth1".

Thus the pulses of the voltage which is not higher then "Vth1" are successively applied to the liquid crystals 21 of pixels in each column of the aforementioned pixel matrix, where the alignment state of the liquid crystals 21 is not changed by the voltage.

The common electrode Y and the island electrode 23 arranged with interposition of the liquid crystals 21 being e dielectric substance are electrostatically coupled. Therefore, e voltage is induced at the common electrode Y due to the pulse voltage applied to the island electrode 23. In the above case, the magnitude of the induction voltage corresponds to the electrostatic capacitance across the island electrode 23 and the common electrode Y. In other words, the greater the electrostatic capacitance across the island electrode 23 and the common electrode Y is, the greater the voltage induced at the common electrode Y will be.

Since the distance between the island electrode 23 and the common electrode Y is constant, the electrostatic capacitance across the island electrode 23 and the common electrode Y varies according to the dielectric constant of the liquid crystals 21. The dielectric constant of the liquid crystals 21 varies according to the alignment state of the liquid crystal molecules as shown in Fig. 4. According to the alignment state of the liquid crystal molecules, the brightness condition to be written is determined. Therefore, the alignment state (i.e, brightness condition) of the liquid crystals 21 can be detected by detecting the voltage induced et the common electrode Y. The voltage signal induced at the common electrode Y is amplified and shaped by the image data detection circuit 9.

Thus the brightness data written into each pixel of the pixel matrix of the image input device-integrated display unit 1 are read as an induction voltage at the common electrode Y.

Specifically, a voltage which is not higher than "Vth1" is successively applied to the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3 in the period when the common electrode Y_1 is selected by the common electrode selection circuit 4 as shown in Fig. 1 to transmit the time series of the read induction voltage pertinent to all the pixels of the common electrode Y_1 to the image data detection circuit 9.

When the brightness data of the pixels in the 1st row and *m* columns are read in the above-mentioned menner, the common electrode Y_2 is selected by the common electrode selection circuit 4 and e voltage which is not higher than "Vth1" is applied to the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3 to read the brightness data of the pixels in the 2nd row and *m* columns.

The above-mentioned operation is repeated to read the brightness data (i.e, image data) of the matrix of pixels in *n* rows end *m* columns as an electric signel.

Although the control light is irradiated from the side of the glass plate 29 in order to make the photoconductor 22 heve e low resistance in the example described above, such a measure is not always required to be taken.

When the ebove measure is not taken, the electrostatic capecitance which generates the induction voltage et the common electrode Y is a synthetic electrostatic capacitance formed by successively connecting the electrostatic capecitance ecross the segment electrode X end the islend electrode 23 with the electrostatic capacitance ecross the Islend electrode 23 end the common electrode Y. Therefore, the induction voltage generated et the common electrode Y depending on the alignment stete of the liquid crystals 21 constituting each pixel exhibits a reduced varience in level end an increased irrelevant DC component voltage.

Because of e greet voltage drop due to the derk resistance of the photoconductor 22, e voltage which is not lower then "Vth1" can be applied across the segment electrode X end the common electrode Y to allow the reduction of varience in level to be suppressed to some extent.

(4) Image display mode (In which an Imege is written into the Image Input devlce-Integrated display unit by means of en electric signel)

The operetion in the present mode is the seme es in the image displey mode of the conventionel liquid crystal displey.

Fig. 8 shows e schematic sectionel view of the imege input device-integrated displey unit 1, where elements irrelevent to the imege display mode are eliminated.

Illumination light Is irradieted by the back light 11 from the side of the gless plate 29. Then the incident light strikes on the photoconductor 22 to meke the photoconductor 22 heve a low resistance, with which the Island electrode 23 and the segment electrode X are mede to have en epproximetely equel potentiel. Therefore, e voltage epproximetely equal to the voltage applied to the segment electrode X eppeers at the islend electrode 23.

First, the common electrode Y_1 in the 1st row is selected by the common electrode drive circuit 2 to receive e specified voltage. In the above condition, e voltage corresponding to imege deta is epplied to the segment electrode X_a by the segment electrode drive circuit 3 besed on e dlsplay signel from the aforementioned display control circuit 6 (refer to Fig. 1). Consequently, an approximately equel voltage is applied to the Islend electrode 23_a, while e voltage epproximetely equel to the voltage ecross the segment electrode X_a end the common electrode Y_1 (the voltage referred to as the "displey voltage" hereinefter) is epplied to the liquid crystals 21 in the area of the islend electrode 23_a.

Therefore, when the ebove-mentioned displey voltage is not lower then "Vth1" end lower then "Vth2" as shown In Fig. 3, the liquid crystals 21 in the relevent pixel eree ere put into the focalconlc state end derk data ere written into the liquid crystals. In contrast to the above, when the display voltage is not lower then "Vth2", the liquid crystals 21 in the relevant pixel erea ere put into the homeotropic orientation end light deta are written into the liquid crystals.

Then e voltage corresponding to Image deta is applied to the segment electrode X_b by the segment electrode drive circuit 3. Consequently, a voltage approximately equal to the display voltage is applied to the liquid crystals 21 in the erea of the relevant island electrode 23_b, end light deta or dark deta are written into the relevent liquid crystals 21 eccording to the displey voltage.

By repeeting the ebove-mentioned operation, voltages corresponding to the image deta are successively written into the segment electrodes X_1, X_2, ... X_m under the control of the segment electrode drive circuit 3, with which the imege Is written into the pixels in the 1st row end *m* columns of the aforementioned pixel matrix.

Then, the common electrode Y_2 in the 2nd row is selected by the common electrode drive circuit 2 to receive a specified voltage. In the above condition, voltages corresponding to the image deta are successively epplied to ell the segment electrodes X_1, X_2, ... X_m by the segment electrode drive circuit 3, with which the Image is written into the pixels in the 2nd row end *m* columns.

Subsequently, the ebove-mentioned operation is repeeted to write the imege into the metrix of pixels in *n* rows end *m* columns to displey the imege.

The above ere the principle of operations In each of the image input mode, pen input mode, image reed mode, end imege displey mode of the Image Input device-Integrated displey unit 1 employing phese transition type liquid crystals es the liquid crystals 21.

In the present embodiment es described ebove, phese transition type liquid crystals ere interposed between the common electrode Y formed vie the light-shielding film 25 on the gless plete 28 and the islend electrode 23 of each pixel electrically connected vie the photoconductor 22 to the segment electrode X formed on the glass plete 29 to constitute the image input device-integrated displey unit 1.

In the image input mode, the phese transition type liquid crystals In ell the pixels of the pixel matrix composed of the ereas of intersections between a plurality of segment electrodes X end a plurality of common electrodes Y are put into the Grandjean state under the control of the display control circuit 6, Image input control circuit 8, end back light control circuit 12. Subsequently, reflection light from the white erea of the document 31 is mede to strike on the photoconductor 22 to meke the photoconductor 22 heve e low resistance to thereby put the phase transition type liquid crystals of the pixels on which the reflection light strikes into the focalconlc state.

Thus the optical Image of the document is copied

into the pixel matrix.

In the pen input mode, the phese transition type liquid crystals in all the pixels of the pixel matrix ere put into the Grandjeen state under the control of the displey control circuit 6, image input control circuit 8, and beck light control circuit 12. Subsequently, reflection light of the light from the light source 41 of the input pen 10 is mede to strike on the photoconductor 22 to meke the photoconductor 22 heve e low resistance to thereby put the phese transition type liquid crystals of the pixels at which the pen input took plece into the focalconic state.

Thus the image is written into the abovementioned pixel metrix by means of the input pen 10.

In the Image read mode, the control light from the back light 11 is made to strike on the photoconductor 22 to meke the photoconductor 22 heve e low resistance to thereby scan the island electrodes 23 successively with e voltege such thet it does not chenge the stete of the phese transition type liquid crystals under the control of the imege dete detection control circuit 7 and the back light control circuit 12. In the abovе time, each common electrode Y is successively selected by the common electrode selection circuit 4 to detect the time series of the voltage induced et the common electrode Y by means of the imege deta detection circuit 9.

Thus the imege deta of eech pixel constituting the eforementioned pixel metrix (i.e., the alignment state of the phase transition type liquid crystals) are taken out es en electric signel corresponding to the alignment stete of the phese transition type liquid crystals pertinent to the pixel.

In the imege displey mode, voltages corresponding to the imege deta ere epplied to ell the segment electrodes X_1 through X_m while successively selecting eech common electrode Y under the control of the display control circuit 6 and the beck light control circuit 12. In the abovе time, the control light from the beck light 11 is mede to strike on the photoconductor 22 to meke the photoconductor 22 heve e low resistance to thereby apply e voltege corresponding to the imege deta to the phese transition type liquid crystals of the relevent pixels constituting the pixel matrix, with which the elignment state of the phese transition type liquid crystals of the relevent pixels is put into en alignment stete corresponding to the imege dete.

Thus an Image corresponding to the imege deta is written into the abovе-mentioned pixel metrix to displey the imege.

Therefore, according to the Image input device-integrated type displey device employing the image input device-Integrated display unit 1 of the present embodiment, the imege displey function, document optical image copying function, displey imege reed function, end the pen input function can be provided by one device.

Second embodiment

Then the following describes the operation of the imege input device-integrated displey unit 1 employing e current/electric field effect type liquid crystals es the liquid crystals 21 in regard to eech mode. The liquid crystals of the above type ere n-type cholesteric liquid crystals, liquid crystals formed by mixing the n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals.

It is noted thet the Imege Input device-Integrated displey unit of the present embodiment hes utterly the same construction as thet of the Image Input device-integrated displey unit 1 es shown in Fig. 2 except for the liquid crystals. Therefore, the following description is made with reference to Fig. 2.

Before expleining the operation, reference is first mede to a chenge of the elignment state of the liquid crystals.

Figs. 9 (e) through 9 (d) schemetically show e chenge of the stete of the current/electric field effect type liquid crystels.

Referring to Fig. 9 (e), in the initiel state, the helical axes of the cholesteric liquid crystal molecules ere in the Grandjean state where the helical axes ere eligned in a direction perpendiculer to the electrode surfeces, when the current/electric field effect type liquid crystals (referred to merely es the "liquid crystals" in the present embodiment) ere transparent.

Then referring to Fig. 9 (b), when e DC voltage or e low-frequency AC voltage is epplied to the liquid crystels end the voltege is gradually Increased, the negetive ions incorporated into the liquid crystals move et a voltege which is not lower then a threshold voltage. With the abovе-mentioned operation, the helicel axes eligned in e direction ere disordered to be directed in Irreguler directions to be in the focalconic state. In the focalconic state, the liquid crystals ere optically opeque.

The focalconic state is stored even when the electric field is removed es shown in Fig. 9 (c).

In order to erase the elignment state of the liquid crystals thus stored, a voltage having e high frequency (several kilohertz) et which no current effect is generated is epplied to the liquid crystals as shown in Fig. 9 (d). With the above-mentioned operation, the liquid crystel molecules directed in Irreguler directions ere eligned in e direction to be restored into the Grandjeen state.

The abovе-mentioned liquid crystal molecules have an anisotropy of dielectric constant, end therefore the dielectric constant of the entire liquid crystal cell chenges depending on the elignment state of the liquid crystal molecules.

(1) Image input mode

In e first step, the liquid crystals 21 are entirely

put into the transparent state (i.e., the aforementioned Grandjean state).

Control light is irradiated by the back light 11 from the side of the glass plate 29, and a voltage having a high frequency (several kilohertz) at which no current effect is generated is applied across the segment electrode X and the common electrode Y under the control of the display control circuit 6. In the above time, the voltage may be applied either successively or simultaneously. Consequently, the liquid crystals 21 are put into the Grandjean state to be entirely transparent, i.e., put into the initial state before the write operation.

In a second step, the reflection light from the document is copied into the liquid crystals 21.

The above-mentioned document is placed under the glass plate 29 with the document closely fit to the glass plate 29. Under the control of the image input control circuit 8, a DC voltage or a low-frequency AC voltage which is not lower than the threshold voltage at which the liquid crystals 21 are transformed into the focalconic state by the current effect is applied successively or simultaneously across each segment electrode X and each common electrode Y. Then by irradiating document illumination light by means of the back light 11 from the side of the glass plate 28, the light transmitted through the image input device-integrated display unit 1 is converged on the surface of the document by the micro lens 27.

In the case where the convergence light strikes on a white area of the document, the reflection light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance. Then a voltage approximately equal to the DC voltage or the low-frequency AC voltage which is not lower than the aforementioned threshold voltage applied across the segment electrode X and the common electrode Y is applied across the island electrode 23 and the common electrode Y (i.e., to the liquid crystals 21), with which the liquid crystals 21 are transformed from the Grandjean state where the liquid crystals are transparent to the focalconic state where the liquid crystals are turbid whitely.

In other words, the white area of the document is invertedly written into the liquid crystals 21 as a black area.

In contrast to the above, in the case where the convergence light strikes on a black area of the document, no reflection light strikes on the photoconductor 22 to allow the photoconductor 22 to remain having a high resistance. In the above time, by setting the dark resistance of the photoconductor 22 at a value such that it becomes higher than the resistance of the liquid crystals 21, a great voltage drop due to the photoconductor 22 results to apply almost no voltage across the island electrode 23 and the common electrode Y. Therefore, the liquid crystals 21 maintain the initial Grandjean state to be transparent.

In other words, the black area of the document is invertedly written into the liquid crystals 21 as a white area.

Thus the negative image of the document is written into the matrix of $n \times m$ pixels of the image input device-integrated display unit 1.

(2) Pen input mode

The liquid crystals 21 are put into the initial state in the same manner as in the aforementioned image input mode. Subsequently, under the control of the image input control circuit 8, a DC voltage or a low-frequency AC voltage which is not lower than the threshold voltage at which the liquid crystals 21 are transformed into the focalconic state is applied successively or simultaneously across each segment electrode X and each common electrode Y. It is noted that the principle of the pen input operation is the same as the principle of operation in the aforementioned image input mode.

When the pen touch switch 45 of the input pen 10 having a structure as shown in Fig. 6 is turned on, light is emitted from the light source 41. Then the light from the light source 41 is transmitted through the image input device-integrated display unit 1 and reflected on the white sheet placed under the glass plate 29 to be incident on the photoconductor 22.

Consequently, the resistance of the photoconductor 22 is reduced to make the electric potential at the island electrode 23 be approximately equal to the electric potential at the segment electrode X, and the DC voltage or the low-frequency AC voltage which is not lower than the aforementioned threshold voltage is applied to the liquid crystals 21 constituting the relevant pixel. Thus the liquid crystals 21 are transformed into the focalconic state (where the liquid crystals are turbid whitely).

Subsequently, when the input pen 10 is moved out of the relavant pixel area or the input pen 10 is put apart from the image input device-integrated display unit 1 to turn off the pen touch switch 45, no light is incident on the relevant pixel to make the resistance of the photoconductor 22 be the dark resistance. Consequently, a great voltage drop takes place at the photoconductor 22, with which the voltage applied to the liquid crystals 21 is made to be "0".

Thus the liquid crystals 21 in the relevant pixel area which are put into the focalconic state by the pen input maintains the focalconic state. In other words, dark data are written into the liquid crystals 21 in the relevant pixel area by the pen input.

By time-sharingly processing the above-mentioned pen input mode and the image read mode as described hereinafter, the coordinates of the pixel currently designated by the input pen 10 can be detected.

In order to erase the image data already written,

a voltage which hes e high frequency (several kilohertz) not lower then the aforementioned threshold value is required to be applied across the segment electrode X and the common electrode Y to put the liquid crystals 21 of the pixels traced by the input pen 10 into the Grandjean state.

(3) Image read mode

Control light is irradiated by the back light 11 from the side of the glass plete 29 of the Imege Input device-integrated display unit 1. Then the incident light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance.

In the ebove condition, pulses of e DC voltage or e low-frequency AC voltage not higher than the aforementioned threshold voltage is successively applied to each of the segment electrodes X_1, X_2, ... X_m by means of the segment electrode drive circuit 3 under the control of the aforementioned image data detection control circuit 7. In the above time, since the photoconductor 22 has a low resistance, the island electrode 23 is scanned by a pulse having a voltage approximetely equal to the voltege epplied to the segment electrode X. In the above case, the abovementioned DC voltage or the low-frequency AC voltage not higher than the aforementioned threshold value is applied to the liquid crystals 21, and therefore the elignment state of the liquid crystels 21 does not chenge.

Consequently, a voltege is induced at the common electrode Y due to the pulse voltage epplied to the island electrode 23 which is electrostatically coupled with the aforementioned common electrode Y. In the above case, the magnitude of the induction voltage corresponds to the electrostatic capacitance generated across the island electrode 23 and the common electrode Y. Since the distance between the island electrode 23 and the common electrode Y is constant, the electrostetic capecitence across the island electrode 23 end the common electrode Y veries according to the dielectric constant of the liquid crystals 21.

The dielectric constant of the liquid crystals 21 veries according to the elignment state of the liquid crystal molecules. The alignment state of the liquid crystal molecules determines the brightness condition of the data to be written.

Therefore, by detecting the voltage induced by selecting one common electrode Y while the segment electrodes X_1 through X_m ere scanned once, the alignment state of the liquid crystals 21 of the pixels in the 1st row end *m* columns provided in the position of the common electrode Y (i.e., the brightness condition of the pixel) can be detected in time series.

Thus by scanning the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3 every time selecting successively each of the common electrode Y_1 through Y_n by means of the common electrode selection circuit 4, Image data of the matrix of the pixels in *n* rows and *m* columns are read as an electric signal.

It is noted thet the control light for meking the photoconductor 22 have a low resistance is not always required to be irradiated in the abovementioned Image read mode.

(4) Image display mode

Illumination light is irradiated by the back light 11 from the side of the glass plete 29. Then the photoconductor 22 is mede to heve e low resistance to make the island electrode 23 heve epproximately equal electric potential es the electric potential at the segment electrode X.

In the above condition, each common electrodes Y is successively selected by the common electrode drive circuit 2 under the control of the display control circuit 6 to set the common electrode Y at a specified electric potential. Then all the segment electrodes X_1 through X_m are successively scanned by the segment electrode drive circuit 3 while e specified common electrode is selected to apply the aforementioned DC voltage (or the low-frequency AC voltage) or a high-frequency (several kilohertz) not lower then the threshold value to each of the segment electrodes X_1 through X_m according to the image deta.

Consequently, the pixels relevent to the liquid crystels 21 to which the DC voltage (or the low-frequency AC voltage) not lower than the aforementioned threshold value is applied among the pixels constituting the aforementioned pixel matrix exhibit a dark display. Meanwhile, the pixels relevant to the liquid crystals 21 to which the high-frequency voltage is applied exhibit e light displey. Thus en Image corresponding to the eforementioned imege deta is displeyed on the ebove-mentioned pixel matrix.

Third embodiment

Then the following describes the principle of operation of the image input device-integrated display unit 1 employing ferroelectric liquid crystals es the liquid crystals 21 in regerd to each mode.

Fig. 10 is a sectional view showing the structure of an image input device-integrated type display unit 1 of the present embodiment taken along the common electrode Y, where the seme components as those in Fig. 2 are denoted by the same numerals end no detelled description therefor is provided herein.

The above-mentioned ferroelectric liquid crystals ere in either of only two stable states in the case where they are encapsuleted in e cell heving a thickness of several micrometers. The liquid crystals heve the characteristic of storing either of the stable states in which they are.

In the above case, the ebove-mentioned two stable states include the state in which the ferroelectric liquid crystals are directed in one direction (assumed to be a direction A) and the state where the ferroelectric liquid crystals are directed in the other direction (assumed to be a direction B) in a plane in parallel with the eforementioned cell. When a polarization plete is placed with its polerization direction directed in a direction perpendicular to one (assumed to be the direction A) of the two directions, the ferroelectric liquid crystals of which molecules ere directed in the direction (direction A) produce a transmission light having a low intensity. The ferroelectric liquid crystals of which molecules are directed in the other direction (direction B) produce a transmission light heving e high intensity. It is noted that the two directions (direction A and direction B) are not always perpendicular to each other in the above case.

A transition between the above-mentioned two stable states can be effected only by changing the polerity of the voltege to be applied to the liquid crystals.

Referring to Fig. 10, there are included ferroelectric liquid crystals 51, a photoconductor 22, an island electrode 23, a segment electrode X, and a common electrode Y. It is noted thet the segment electrode X, the common electrode Y, end the islend electrode 23 are transparent electrodes mede of ITO (indium tin oxide).

A polarizer 52 is formed on the common electrode Y on the photoconductor 22. The polarization direction of the polarizer 52 is in the same direction as that of the common electrode Y in the plene of the peper on which Fig. 10 is illustrated, the polerization direction indicated by an arrow "← →" as shown in Fig. 10.

The ferroelectric liquid crystals 51 exhibit two stable molecule eligments in a plane which is perpendicular to the plane of the paper and in parallel with the polerization direction of the polarizer 52. One of the elignments is e molecular elignment in e direction perpendicular to the polerization direction of the polarizer 52, the molecular alignment indicated by "•" as shown in Fig. 10. The other is the molecular alignment in a direction approximately in parallel with the polerizing element of the polarizer 52, the molecular elignment indicated by "← →".

Therefore, when the polarization direction of the polerizer 52 and the molecular elignment direction of the ferroelectric liquid crystals 51 are the combination of "← →" and "•", the polerization direction of the polarizer 52 and the elignment direction of the ferroelectric liquid crystels 51 ere perpendiculer to each other, and therefore e laminate of the polarizer 52 and the ferroelectric liquid crystals 51 ellows less light to be transmitted therethrough. In contrast to the ebove, when the above-mentioned combinetion is of "← →" and "← →", the polerization direction of the polarizer 52 and the alignment direction of the ferroelectric liquid crystals 51 ere approximetely in parallel with each other, and therefore the leminete of the polerizer 52 and the ferroelectric liquid crystals 51 allows more light to be transmitted therethrough.

The two elignment directions of "← →" and "•" of the ferroelectric liquid crystals 51 can be controlled by inverting the polarity of the voltage applied across the common electrode Y end the islend electrode 23. It is essumed in the present embodiment that the elignment direction of the ferroelectric liquid crystals 51 is "•" when the common electrode Y is in the negetive polarity end the island electrode 23 is in the positive polarity, and conversely the alignment direction of the ferroelectric liquid crystals 51 is "← →" when the common electrode Y is in the positive polarity and the islend electrode 23 is in the negative polarity.

(1) Image input mode

Figs. 11 (a) through 11 (d) show the operation of the image input devlce-integrated displey unit 1 in the image input mode.

In a first step, the alignment direction of the entire ferroelectric liquid crystals 51 is put in the state of "•" as shown in Fig. 11 (a).

Control light is irradieted on the entire surface of the liquid crystals by the back light 11 from the side of the glass plate 29 to epply a negative voltage to the common electrode Y end a positive voltage to the segment electrode X from the power source 30 under the control of the display control circuit 6. In the above case, the voltages may be applied either successively or simulteneously. Consequently, the photoconductor 22 on which the control light strikes is made to have a low resistance, with which the island electrode 23 and the segment electrode X are mede to have an equal voltage, while the alignment direction of the ferroelectric liquid crystals 51 is made to be entirely "•", i.e., in the initiel state before the write operation.

In e second step, reflection light from a document is copied into the ferroelectric liquid crystals 51.

In a manner as shown in Fig. 11 (b), the document 31 is placed under the glass plate 29 with the document closely fit to the glass plete 29. Under the control of the Image Input control circuit 8, a positive voltage is applied to the common electrode Y and a negative voltage is applied to the segment electrode X from the power source 30. In the above case, the voltages may be applied either successively or simultaneously. Then polarized illumination light having a polarization direction of "•" is irradiated on the entire surface of the liquid crystals from the side of the glass plete 28.

Consequently, the polarization direction of the polerized illumination light is perpendicular to the polarization direction of the polarizer 52, and therefore the polerized illumination light does not enter into a

portion directly below the polerizer 52. In other words, the polarized illumination light from above does not reech the polerizer 52. Meanwhile, the alignment direction of the ferroelectric liquid crystals 51 is the seme as the polarization direction of the polerized illumineton light. Therefore, the polerized illumination light which enters from the eree of the transparent insuletor 26 except for the polerizer 52 and is transmitted through the common electrode Y to reach the ferroelectric liquid crystals 51 is transmitted through the ferroelectric liquid crystals 51. The polerized illumination light is further transmitted through the lsland electrode 23 and the segment electrode X to be converged on the surface of the document by the micro lens 27.

In the case where the convergence light strikes on e white area of the document 31, reflection light strikes on the photoconductor 22 to make the photoconductor 22 heve a low resistence. Then the electric potentiel et the islend electrode 23 is mede to be epproximetely equal to the electric potentiel et the segment electrode X to epply the positive voltage to the common electrode Y end the negative voltage to the islend electrode 23. Consequently, the elignment direction of the ferroelectric liquid crystels 51 chenges from the stete of "•" to the state of "← →" as shown in Fig. 11 (c).

In other words, the white area of the document 31 is written into the ferroelectric liquid crystals 51 es the alignment state of "← →".

In contrast to the ebove, in the case where the convergence light strikes on a bleck area of the document 31, no reflected light strikes on the photoconductor 22 es shown in Fig. 11 (d), end therefore the photoconductor 22 remelns heving e high resistance (derk resistance). In the ebove case, by meking the derk resistance of the photoconductor 22 have e resistance higher then the resistance of the ferroelectric liquid crystals 51, e greet voltage drop due to the photoconductor 22 results to apply elmost no voltage ecross the island electrode 23 and the common electrode Y. Therefore, the alignment direction of the ferroelectric liquid crystals 51 is meintained in the state of "•".

In other words, the black aree of the document 31 is written into the ferroelectric liquid crystals 51 es the alignment state of "•".

Thus the optical imege of the document 31 where the two elignment directions of the ferroelectric liquid crystals 51 exist mixedly is written into the metrix of $n \times m$ pixels of the imege input device-integrated display unit 1 and then temporarily stored. Therefore, in viewing the imege copied into the above-mentioned pixel metrix, e positive imege disploy results when the polerization direction of the display illumineton light irradieted from the side of the gless plate 29 is "← →", while a negative imege displey results when the polerization direction is "•".

(2) Pen input mode

Figs. 12 (e) through 12 (c) show the operation of the image input device-integrated display unit 1 in the pen input mode.

In e first step, the elignment direction of the entire ferroelectric liquid crystals 51 is put in the state of "← →" as shown in Fig. 12 (a).

Control light is irradieted on the entire surface of the liquid crystals by the back light 11 from the side of the glass plete 29 to apply a positive voltage to the common electrode Y end e negetive voltage to the segment electrode X from the power source 30 under the control of the displey control circuit 6. In the above case, the voltages may be epplied either successively or simultaneously. Consequently, the photoconductor 22 on which the control light strikes is made to heve e low resistance, with which the lsland electrode 23 end the segment electrode X ere mede to have an equal voltage, while the alignment direction of the ferroelectric liquid crystals 51 is made to be entirely "← →", i.e., in the initial state before the write operation.

In e second step, an image is written on the pixel metrix by means of the input pen 10.

Under the control of the image input control circuit 8, e negetive voltege is applied to the common electrode Y and e positive voltage is epplied to the segment electrode X from the power source 30 as shown in Fig. 12 (b). In the above case, the voltages may be epplied either successively or simultaneously.

In the above condition, the tip of the input pen 10 having e structure as shown in Fig. 6 is pressed egeinst e pen input position on the image input device-integrated display unit 1. Then the pen touch switch 45 is turned on to emit light from the light source 41. The light from the light source 41 is circularly polerized light, and therefore the light is transmitted through the polerizer 52 to directly strike on the photoconductor 22. Consequently, the photoconductor 22 is mede to heve a low resistance to meke the islend electrode 23 end the segment electrode X have en equel electric potential, with which the elignment direction of the ferroelectric liquid crystals 51 is transformed from the initial state of "← →" to the state of "•".

Subsequently, when the input pen 10 is moved out of the relevent pixel aree or the input pen 10 is put apart from the image input device-integrated display unit 1 to turn off the pen touch switch 45, no light is incident on the relevant pixel to make the resistance of the photoconductor 22 be the derk resistance. Consequently, e great voltage drop takes piece at the photoconductor 22, with which the voltage applied to the ferroelectric liquid crystals 51 is made to substantially be "0".

Thus the ferroelectric liquid crystals 51 of which

alignment direction is "e" by the pen input meintains their alignment state. In other words, Image data ere written end stored into the ferroelectric liquid crystals 51 in the relevent pixel erea by the pen input. It is noted that the islend electrode 23 is charged with positive electric cherges in the ebove case es shown in Fig. 12 (c).

In contrast to the ebove, the ferroelectric liquid crystels 51 in the pixel eree where no pen input took place maintain the initial state of "← →", while the island electrode 23 is not charged with electric charges.

By time-sharingly processing the above-mentioned pen input mode and the imege read mode es described hereinefter, the coordinetes of the pixel et which the input pen 10 is designating can be detected.

In order to erase the image already written, a negative voltage is applied to the segment electrode X and a positive voltege is epplied to the common electrode Y to change the alignment direction of the ferroelectric liquid crystals 51 in the pixel area which was traced by the input pen 10 into the state of "← →".

In the pen input mode of the aforementioned first and second embodiments, an image is written into the liquid crystals by means of reflection light from the input pen 10, and therefore a white- sheet is necessary as a reflective object. However, in the pen input mode of the present embodiment, en image is directly written into the ferroelectric liquid crystals 51 by meens of light from the input pen 10, end therefore no white sheet is necessery es a reflective object.

(3) Document imege read mode

The document image reed mode is the mode for reading brightness data of a document es an electric signal.

Figs. 13 (a) through 13 (c) show the operetion of the imege input device-integrated display unit 1 in the document image reed mode.

In a first step, the elignment direction of the entire ferroelectric liquid crystals 51 is put into the initiel state of "← →" es shown in Fig. 13 (a).

Control light is lrradiated on the entire surface of the lliquid crystals by the back light 11 from the side of the glass plete 29. Under the control of the display control circuit 6, a positive voltage is applied to the common electrode Y and e negetive voltege is applied to the segment electrode X from the power source 30. Consequently, the island electrode 23 and the segment electrode X ere made to have an equal voltage, with whlch the alignment direction of the entire ferroelectric liquid crystals 51 is put into the state of "← →". Subsequently when irradiation of the control light is stopped, the islend electrode 23 is charged with negative electric charges. The above-mentioned state is the initiel state.

In a second step, reflection light from the document is copied into the ferroelectric lliquid crystals 51.

In a menner es shown in Fig. 13 (b), polerized lliumination light heving e polarization direction of "e" perpendicular to the polarization direction of "← →" of the polarizer 52 is irradiated from the side of the glass plate 28. Meanwhlle, a document 31 is pleced under the glass plete 29 with the document closely fit to the glass plate 29. Under the control of the image input control circuit 8, e positive voltage is applied to the segment electrode X and e negative voltage is epplied to the common electrode Y from the power source 30. It is noted thet the voltage applied to the ferroelectric liquid crystals 51 is a voltage which is lower than such a threshold voltage that it does not change the alignment direction.

Since the polerization direction of "← →" of the polarizer 52 end the polerization direction of "e" of the polarized illumination light ere perpendicular to each other, the photoconductor 22 is not directly illuminated the polerized illumination light. Besides, the two possible alignment directions- of the ferroelectric lliquid crystals 51 ere not perfectly perpendicular to each other for the reason as described ebove. Therefore, the polarization direction of the polerized illumination light and the alignment direction of the ferroelectric liquid crystals 51 ere not perfectly perpendiculer to eech other, which results in e smell quentity of light transmitted from the ferroelectric liquid crystals 51. The transmission light is used to illuminete the document 31.

When there is reflection light from the document 31, the resistance of the photoconductor 22 is reduced. In the above case, e positive voltage which is not higher than the threshold value is applied to the segment electrode X. Therefore, the negetive electric cherges charged et the lsland electrode 23 leak by wey of the photoconductor 22. Consequently, the quentity of negative charges et the islend electrode 23 is reduced. When there is no reflection light from the document 31, the resistance of the photoconductor 22 keeps the dark resistance. Therefore, the lsland electrode 23 is still charged with the negative electric charges built up in the initiel state.

Thus the monochrome deta of the eforementioned document 31 ere copied as- data of electric charges at the lsland electrode 23.

In either of the above-mentioned cases, the elignment direction of the ferroelectric liquid crystals 51 does not change.

In a third step, the image data copied into the lsland electrode 23 are converted into an electric signal.

In e menner es shown in Fig. 13 (c), control light having a polerization direction of "← →" in parallel with the polarization direction of "← →" of the aforementioned polarizer 52 is irradiated from the side of the glass plate 28. Under the control of the image

data detection control circuit 7, a negative voltage is applied to each segment electrode X and a positive voltage is applied to each common electrode Y from the power source 30.

Then a load resistor is inserted in a portion of the electric circuit composed of the aforementioned power source 30, common electrode Y, and segment electrode X.

In the pixel where the quantity of electric charges at the island electrode 23 is reduced by the reflection light from the document 31 in the above-mentioned second step, negative charges are supplemented to the island electrode 23 from the segment electrode X to which the negative voltage is applied. In the above case, a current flows through the aforementioned electric circuit, and therefore an electric potential difference takes place across the terminals of the load resistor.

In contrast to the above, in the pixel where the quantity of the electric charges at the island electrode 23 is not reduced because of no reflection light from the document 31, the negative charges are not supplemented to the island electrode 23 from the segment electrode X, and therefore no electric potential difference takes place across the terminals of the load resistor.

In a third step, the above-mentioned load resistor is practically connected to the segment electrode X, and the aforementioned control light having the polarization direction of "← →" is irradiated on each common electrode Y one by one. Then the control light is irradiated successively onto the common electrode Y_1 through the common electrode Y_n to scan the common electrode Y. By successively detecting the electric potential differences across the terminals of the load resistor connected to each of the segment electrodes X_1 through X_m when the control light is irradiated on a certain common electrode Y, the charge conditions of the island electrode 23 in (m) pixels provided at the position of the common electrode Y (i.e., the presence or absence of reflection light from the document 31, which is equal to the brightness condition of the document 31) can be read as a time series of an electric signal.

Fig. 14 shows the concept of the operation of the image input device-integrated display unit 1 in the document image read mode. The electric circuit composed of the aforementioned power source 30, common electrode Y, and segment electrode X can be expressed by an equivalent circuit as shown in Fig. 14 (a).

In more detail, a capacitor 55 is the electrostatic capacitance across the above-mentioned common electrode Y and the island electrode 23. A switch 56 is the photoconductor 22 which is made to have a low resistance (i.e., "on" condition) when it receives light to make the electric potential at the island electrode 23 equal to the electric potential at the segment electrode X. A power source 57 is the aforementioned power source 30.

First, control light is temporarily irradiated on the above-mentioned switch 56 to turn on the switch 56 and thereby charge the capacitor 55 with electric charges (aforementioned first step).

Then, as shown in Fig. 14 (b), the electric charges in the capacitor 55 is made to leak by removing the power source 57 (making the voltage applied to the ferroelectric liquid crystals 51 from the power source 30 be not higher than the threshold voltage) and thereby turning on the switch 56. In the above case, turning-on and turning-off operations of the switch 56 are controlled by the reflection light from the document 31 (aforementioned second step).

Then, as shown in Fig. 14 (c), the aforementioned power source 57 is inserted again and a load resistor R_L is inserted in between the switch 56 and the power source 57. The switch 56 is turned on to supplement the electric charges leaked from the capacitor 55 by means of the power source 57. Then, in a capacitor 55 from which the electric charges have leaked, a current flows to supplement the leak electric charges to generate an electric potential difference across the terminals of the load resistor R_L. In contrast to the above, in a capacitor 55 from which no electric charges have leaked, no current flows to generate no electric potential difference across the terminals of the load resistor R_L (aforementioned third step).

Therefore, by detecting the electric potential difference across the terminals of the above-mentioned load resistor R_L, the optical image of the document 31 can be read as an electric signal.

It is noted that the turning-on and turning-off of the switch 56 is controlled by the control light irradiated on each common electrode Y one by one.

(4) Image read mode

The operation of the image input device-integrated display unit 1 in the image read mode is basically the same as in the aforementioned document image read mode.

Fig. 15 (a) shows the condition of the image input device-integrated display unit 1 relevant to the pixel immediately after image data are written into the matrix of $n \times m$ pixels by the input pen 10 in the aforementioned pen input mode. The condition shown in Fig. 15 (a) is the same as the condition shown in Fig. 12 (c), where the island electrode 23 is charged with positive electric charges.

Then, as shown in Fig. 15 (b), a linear control light is irradiated on each common electrode Y one by one from the side of the glass plate 29 of the image input device-integrated display unit 1 to scan the common electrodes Y_1 through Y_m. Under the control of the image data detection control circuit 7, a negative voltage is applied to each segment electrode X and a

positive voltage is applied to each common electroda Y from tha power source 30. In tha above casa, each of tha voltagas applad to the ferroelectric liquid crystals 51 is a voltage which is not higher than the threshold value at which the alignmant direction of the ferroelectric liquid crystals 51 is not changed.

Than a load resistor is inserted in a portion of the alactric circuit composad of the aforemantioned powar source 30, common electrode Y, and segment alectroda X.

As described above, the island electrode 23 relevant to the pixel at which the pan input took place is charged with positiva alactric charges. Therefore, control light is irradiated on tha photoconductor 22 to make tha island electrode 23 and tha segment alectroda X hava an equal alectric potential. Then a negativa voltaga is applied to the segment electrode X and a positiva voltage is applied to tha common electrode Y, with which a current flows through the aforementioned electric circuit to produce an electric potantial difference across the terminals of the aforemantioned load resistor.

In contrast to the above, the island electrode 23 relevant to the pixel at which no pen input took place is not charged with positive electric charges. Therefore, no currant flows through the aforemantioned electric circuit to produce no electric potential difference across the terminals of the aforementioned load resistor.

Thus by detecting the electric potential differance across tha tarminals of tha aforamantionad load resistor, the image data written into the pixel matrix of tha image input davice-integrated display unit 1 by the input pan 10 can ba read as an electric signal.

(5) Imaga display mode

The imaga display mode is the mode in which imaga data are written into tha pixel matrix of tha image input device-integrated display unit 1 according to an alactric signal. It is noted that the principla of image display operation by means of tha imaga input davice-integratad display unit 1 is tha sama as the principla of image display operation of the conventional simple matrix type liquid crystal display.

In a mannar as shown in Fig. 16 (a), control light having a polarization direction of "← →" is irradiatad by the back light 11 from the eide of the glass plate 29. Consequently, tha photoconductor 22 on whlch the illumination light strikas is mada to hava a low resistance to make tha island electrode 23 and the segment alectrode X hava an aqual electric potential. In tha above condition, a negative voltage is applied to aach segmant electrode X and a positive voltage is applied to each common electroda Y from tha power source 30 under the control of the display control circuit 6. In tha above time, a voltaga whlch is not lowar than a threshold value at whlch tha alignment direction of the ferroelectric liquid crystals 51 is changed is applied to the ferroelectric liquid crystals 51. Consequently, the alignmant direction of tha farroelectric liquid crystals 51 is made to ba "← →".

In due coursa, tha alignment direction of the farroelectric liquid crystals 51 and the polarization direction of the illumination light ara put in parallal with aach other, with which the illumination light irradiated from tha side of the glass plate 29 is transmitted through tha image input davice-integrated display unit 1.

Than each common alectroda Y is successivaly selected by tha common electroda drive circuit 2 to apply a specified negative voltage from tha powar source 30. Whila a certain common alectroda is selected, a positive voltage is appliad to all tha sagmant alectrodes X_1 through X_m by means of tha sagmant electroda driva circuit 3. In the abova tima, a voltaga which is not lower than tha threshold value at which the alignment direction of the ferroelectric liquid crystals 51 is changed is applied to the segment electroda X relevant to the pixel at which an image is displayed according to image data. Meanwhile, a voltage which is lower than the above-mentioned threshold value is applied to tha sagmant electroda X relevant to tha pixel at which no imaga is displayed.

Consequantly, as shown in Fig. 16 (b), tha alignmant direction of the ferroelactric liquid crystals 51 relevant to tha pixel at which an image is displayed among the pixals constituting the aforamentioned pixel matrix becomes "•" to be perpendicular to tha polarization direction of "← →" of the illumination light. Therefore, tha pixel at which an imaga is displayed axhibits a dark display.

Maanwhila, tha alignmant direction of the ferroalactric liquid crystals 51 relavant to tha pixal at whlch no image is displayed remains "← →" to be approximataly in parallel with the polarization diraction of "← →" of the illumination light. Therefore, the pixel at which no image is displayad exhibits a light display.

In tha above casa, by making tha polarization direction of tha illumination light equal to the polarization direction of tha polarizer 52, tha polarizer 52 is preventad from baing displayed as a black dot.

It is noted that a negative imaga whare the light portion and the dark portion ara inverted can be displayad by making the polarization direction of tha illumination light ba "•" perpendicular to the polarization direction of the polarizer 52. Tha negative image can be also displayad by inverting the polarities of the voltages applied to tha segment alactrode X and tha common alectrode Y with tha polarization direction of tha illumination light kept intact.

As described above, a positiva/negativa invarsion can be achieved through a simple process in the case of the ferroelectric liquid crystals 51.

Fourth embodiment

The micro lens 27 provided at the image input device-integrated display unit 1 in each of the aforementioned embodiments hes e function of condensing the illumination light on the surfece of the document and a function of preventing the cross-talk of the reflection light from the document in the image input mode. However, there is the drawback that the illumination light cannot be effectively used in the image display mode.

In order to solve the above-mentioned drawback, a plate-shaped optical fiber array 61 es shown in Fig. 17 is used. It is noted thet the plate-sheped optical fiber erray 61 is used in plece of the gless plate 29 of the aforementioned image input device-integrated displey unit 1.

The above-mentioned plate-shaped optical fiber array 61 is substantially composed of cylindrical optical fibers 62 eech having a certain length and a grating-shaped partition 63 for partitioning a plurality of optical fibers 62 two-dimensionally arranged in parellel with eech other to hold the optical fibers 62 as formed in a plate shape where the lengthwise direction of the optical fibers extends in the thickness direction of the optical fiber array 61. Each area partitioned by the above-mentioned partition 63 is a pixel area.

The above-mentioned partition 63 is made of en opaque meterial in order to prevent the cross-talk between the pixels. In order to reduce the loss of light, the projection area of the partition 63 is made to be as small as possible.

As shown in Fig. 17, a difference-in-level 64 is provided between one end surface of the optical fibers 62 and an upper surface of the partition 63 at the upper in Fig. 17 (the upper surface referred to as the "surface A" hereinafter). On the other hand, the other end surface of the optical fibers 62 end e lower surface of the pertition 63 ere in an identical plene et the lower in Fig. 17 (the plene referred to es the "surface B" hereinafter). The segment electrode X, the transparent insuletor 24, and so forth are laminated on the surface B.

The plate-sheped optical fiber array 61 having the above-mentioned structure functions as follows in the image input mode.

In the image input mode, a document is placed on the surface A (practically the surface A of the plate-shaped optical fiber erray 61 is placed on the document). In the above case, since the difference-in-level 64 is provided between the end surface of the optical fibers 62 and the upper surface of the partition 63, there is a gep between the end surface of the optical fibers 62 end the surface of the document. By taking edvantage of the gap, illumineticn light is transmitted from the surface B to the surface A by way of the optical fibers 62 positioned at the periphery of each pixel, while reflection light from the document is transmitted from the surface A to the surface B by way of the optical fibers 62 positioned at the center of each pixel.

As described above, the above-mentioned plate-sheped optical fiber array 61 hes an ability of condensing illumination light inferior to the same function of the micro lens 27 in the image input mode, however, it hes a sufficient cross-talk preventing function. There is elmost no loss of illumination light irradiated from the surface A in the Image display mode.

Fifth embodiment

There are three types of lights composed of display illumination light, document illumination light, end control light as light irradiated onto the Image Input device-integrated display unit 1. It is very effective for compacting the image input device-integrated type dispiey device thet one light source can concurrently serve es the above-mentioned three light sources. In view of the above, the Image input device-integrated type display device of the present embodiment is provided with a back light 11 which concurrently serves es the above-mentioned three light sources.

One side portion of the image input device-integrated dispiey unit 1 constituting the above-mentioned image input device-integrated type display device end one side portion of the back light 11 are connected together mutually pivotally around a pivot portion 65 as shown in Fig. 18 (a). The back light 11 is designed to be able to irradiate light outwardly from its both surfaces 11e end 11b.

With the above-mentioned arrangement, by turning the back light 11 by approximately 360° in angle around the pivot portion 65, the back light 11 can irradiate light either on a display surface Ia (on the side of the glass plete 28) or a reflection surface 1b (on the side of the glass plate 29) of the image input device-integrated display unit 1.

For instance, in the initial state of the aforementioned image input mode and the pen input mode, image read mode, or image display mode, the image input device-integrated display unit 1 and the back light 11 are in e relation in position as shown in Fig. 18 (b). Then the illumination light from the surface 11a of the back light 11 is irradiated on the reflection eurface Ib of the image input device-integrated display unit 1. In the ebove case, the light from the surface 11b of the beck light 11 is not necessary, and therefore a reflection plete is erranged on the side of the surfece 11b to make the light from the back light 11 be effectively irradiated on the imege input device-integrated display unit 1.

Then in the eforementioned imege input mode or the document Image read mode of the third embodiment employing ferroelectric liquid crystals, the back

light 11 is turned by approximately 360° in angle around the pivot portion 65 from the position as shown in Fig. 18 (b) to put the image input device-integrated display unit 1 and the back light 11 in a relation in position as shown in Fig. 18 (c). Meanwhile, a document 31 is placed under the reflection surface 8b of the Image Input device-Integrated display unit 1. Thus the document illumination light from the surface 11b of the back light 11 is irradiated on the image display area 8a of the image input device-integrated display unit 1.

In the abova case, the light from the surface 8a of the back light 11 is not necessary, and therefore a reflection plate is arranged on the side of the surface 11a.

By making one back light 11 concurrently serve as the three types of display illumination light source, document illumination light source, and control light source in a menner as described above, the image input device-integrated type display device can be entirely formed very compactly.

As is evident from the above description, the image input device-integrated type display device controls the image input control circuit, document illumination light source, and control light source by means of a control circuit in the image input mode to drive the segment electrode and the common electrode by means of the segment electrode drive circuit and the common alectrode drive circuit based on an image input signal from the above-mentioned imega input control circuit, and controls the turning-on and turning-off of a voltage applied to the liquid crystals of the above-mentioned display unit by means of the light from the above-mentioned light sources to copy tha optical image of a document into the pixel matrix of the above-mentioned display unit. In the Imege read mode, the display device controls the Image read control circuit, image data detection circuit, and the control light source by means of the control circuit to drive the segment electrode and the common electrode by means of the segment electroda dirve circuit and the common electrode drive circuit based on an image read signal from the aforementioned image read control circuit, and turns on the voltage applied to the liquid crystals of the above-mentioned display unit by means of the control light from the above-mentioned control light source to read the image data written in the above-mentioned pixel matrix as an electric signal by means of the above-mentioned image deta detection circuit. In the image display mode, the display device controls the display control circuit and the display illumination light source by means of the control circuit to drive the segment electrode and the common electrode by means of the sagment electrode drive circuit and the common electrode drive circuit based on the display signal from the above-mentioned display control circuit, and turns on the voltage epplied to the liquid crystals of the above-mentioned displey unit by means of the display illumination light from the display illumination light source to display an image corresponding to the above-mentioned display signal on the above-mentioned pixel matrix. With the above-mentioned arrangement, the displey end copy operations of the optical image of the document on the pixel matrix of the abova-mentioned display unit can be achieved under the control of the control circuit.

Therefore, according to tha present invention, a compact integrated Image Input device-Integrated type display device concurrently hevlng an Image display function and a document Image Input function can be provided.

According to an embodiment, there are employad the phase transition type liquid crystals as the above-mentioned liquid crystals. With the above-mentioned arrangement, the change of stata of the liquid crystals according to tha optical imaga of the document in the aforementioned image input mode or the change of state of tha liquid crystals according to the display signal in the aforementioned Image display mode can be achieved by the change of state between the Grandjeen state and the focalconic state of the phese transition type liquid crystals. Furthermore, the read of the electric signal according to tha image data in the aforementioned image read mode can be achieved, when a pulsa is applied to one elactrode of the electrodes interposing therebetween the abova-mentioned phese transition type liquid crystels, by detecting the voltage signal induced at tha other electrode.

Therefore, according to the present invention, a compact integrated image input device-integrated type display device concurrantly having an image display function and a document Imaga Input function can be eesily achieved.

According to an embodiment, there are employed n-type cholesteric liquid crystals, liquid crystels formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals as tha aforementioned liquid crystals. With the above-mentioned errangement, the change of stete of the liquid crystals according to the optical imege of the document in the aforementioned image input mode or the change of state of the liquid crystals according to the display signal in the aforementioned image display moda can be achieved by the change of state between the Grandjaan state and the focalconic state of the n-typa cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals. Furthermore, the read of the electric signal according to the image deta in the aforementioned image reed mode can be achievad, when e pulse is epplied to one electrode of electrodes interposing therebetween the above-mentioned n-type cholesteric liquid crystals, liquid crystals formed

by mixing n-type cholesteric liquid crystals with n-type nemetic liquid crystals, or smectic-A liquid crystals, by detecting the voltage signel induced et the other electrode.

Therefore, according to the embodiment, a compect integrated image input device-integrated type display device concurrently having an image display function end a document image input function can be easily achieved.

According to the image input device-integrated type display device, there is provided a polarizer for controlling the polerization direction of only the light which enters from the side of the electrode which is one of the segment electrode and the common electrode of the display unit and is not electrically connected to the photoconductor before the light reaches the above-mentioned photoconductor. With the above-mentioned arrangement, the resistance of the photoconductor is controlled by the incident light from the ebove-mentioned electrode which is not electrically connected to the photoconductor by e combination of the polarization direction of the light which enters from the side of the above-mentioned electrode which is not electrically connected to the photoconductor and the polarizing element of the aforementioned polarizer, with which the turning-on and turning-off of the voltage applied to the liquid crystals can be controlled.

Therefore, an improved operability can be achieved in the image display operation and the document image input operation in the compect integreted imege input device-integrated type display device concurrently having an imege display function end a document image input function.

According to an embodiment, there are employed ferroelectric liquid crystals as the liquid crystals for use in e display unit heving the aforementioned polerizer. With the ebove-mentioned errangement, the chenge of state of the liquid crystels according to the optical image of the document in the eforementioned image input mode or the change of state of the liquid crystals according to the display signel in the aforementioned imege displey mode can be achieved by the chenge of the elignment direction of the abovementioned ferroelectric liquid crystels.

Therefore, according to the embodiment, there can be easily achieved an image input device-integrated type display device which can control the turning-on end turning-off of the voltage applied to the liquid crystals by the incident light from the electrode which is one of the aforementioned segment electrode and the common electrode and is not electrically connected to the photoconductor.

According to an embodiment, the eforementioned image data detection circuit in the image input device-integrated type display device in which the aforementioned ferroelectric liquid crystals are inserted is designed to detect the quantity of electric charges cherged according to image data at the island electrode in the eforementioned display unit. Meanwhile, the aforementioned control light source is designed to be able to scan one by one each electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor. Furthermore, the control circuit is designed to detect the quantity of electric charges charged at the island electrode of the pixel relevant to one segment electrode or the common electrode selected by being irradiated by light from the aforementioned control light source in the image read mode to read the imege deta written in the above-mentioned pixel matrix as an electric signal. With the above-mentioned arrangement, the imege data of the pixel matrix of the display unit employing the aforementioned ferroelectric liquid crystals can be easily reed as an electric signal.

According to en embodiment, there is provided an input pen which emits light from e light source through its tip end. Meanwhile, the control circuit is designed to control the aforementioned image input control circuit and the control light source in the pen input mode to put the pixel matrix of the aforementioned display unit into the initial state end then drive the segment electrode end the common electrode by means of the segment electrode drive circuit and the common electrode drive circuit according to the eforementioned image input signel while turning on the voltege applied to the liquid crystals of the aforementioned display unit by means of the light from the above-mentioned input pen to change the alignment direction of the liquid crystals of the relevant pixel of the aforementioned pixel matrix. With the abovementioned errangement, an imege can be input to the pixel matrix of the above-mentioned display unit by means of the ebove-mentioned input pen.

Therefore, according to the embodiment, a compect integrated image input device-integrated type displey device concurrently having en image display function, a document image input function, and a pen input function can be provided.

According to en embodiment, there is provided a micro lens on one of the two transparent substrates of the aforementioned displey unit. With the abovementioned errangement, light which enters from the side of the transparent substrate at which the micro lens is not provided, and is irradiated on the abovementioned display unit can be converged.

In more detail, according to the embodiment, a sufficient quentity of light can be irradieted on the aforementioned photoconductor even when the document illumination light or the light emitted from the input pen is reduced at the time when it is reflected, for example, in the aforementioned image input mode or the pen input mode. With the abovementioned errangement, the brightness data of the document end the position deta of the input pen can

be accurately written into the aforementioned pixel matrix.

According to an embodiment, at least one of the transparent substrates of the aforementioned display unit is constructed so that optical fibers each having a specified length are arranged two-dimensionally to constitute a plate-shaped optical fiber array of which axial direction is in the thickness direction of the optical fiber array. With the above-mentioned arrangement, the light which enters from the side of the optical fiber array travels through the above-mentioned optical fibers of the corresponding pixel in the axial direction of the optical fibers.

Therefore, according to the embodiment, an image input device-integrated type display device capable of efficiently executing the operation of each of the aforementioned modes without cross-talk between pixels constituting the pixel matrix of the above-mentioned display unit nor loss in quantity of light.

According to an embodiment, the aforementioned display illumination light source, document illumination light source, and control light source are provided by one plate-shaped light source, and a side portion of the plate-shaped light source is pivotally mounted to a side portion of the aforementioned display unit. With the above-mentioned arrangement, the above-mentioned display unit can be illuminated by the above-mentioned one plate-shaped light source from the front side or the back side of the display unit at need.

Therefore, according to the embodiment, the display illumination light source, document illumination light source, and control light source can be concurrently served by only one plate-shaped light source to allow an integrated image input device-integrated type display device concurrently having at least an image display function and a document image input function to be further compacted.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. An image input device-integrated type display device comprising:

a display unit (1) having a plurality of transparent segment electrodes (X) arranged in parallel with each other on a transparent substrate (29); a plurality of transparent common electrodes (Y) arranged in parallel with each other on another transparent substrate, said common electrodes (Y) being perpendicular to said segment electrodes (X), a photoconductor (22) electrically connected to either the segment electrode (X) or the common electrode (Y) and arranged in a pixel composed of an area of intersection between the segment electrode (X) and the common electrode (Y), a transparent island electrode (23) electrically connected to the photoconductor (22) and arranged in between the segment electrode (X) and the common electrode (Y) relevant to the pixel, liquid crystals (21) interposed between the island electrode (23) and an electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), and a light shielding film (25) for shielding only light applying on the side of the electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22) so that the light does not reach the photoconductor (22);

a display illumination light source (11) which radiates display illumination light in displaying an image on a pixel matrix composed of areas of intersections between the plural segment electrodes (X) and the plural common electrodes (Y) of the display unit (1);

a document illumination light source (11) which radiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit (1);

a control light source (11) which radiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals (21) of the display unit (1);

a display control circuit (6) which generates a display signal for displaying an image on the pixel matrix of the display unit (1);

an image input control circuit (8) which generates an image input signal for copying an optical image of the document into the pixel matrix of the display unit (1);

an image read control circuit (7) which generates an image read signal for reading image data written in the liquid crystals (21) of each pixel constituting the pixel matrix of the display unit (1) in the form of an electric signal;

a segment electrode driving circuit (3) which drives the segment electrode (X) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from the image read control circuit (7);

a common electrode driving circuit (2) which drives the common electrode (Y) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from

the image read control circuit (7);

an image data detection circuit (9) which detects the image data written in the pixel matrix of the display unit (1) in the form of an electric signal; and

a control circuit (13) which copies the optical image of the document into the pixel matrix by controlling the image input control circuit (8), the document illumination light source (11), and the control light source (11) in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit (7), the image data detection circuit (9), and the control light source (11) in an image read mode, and displays an image on the pixel matrix by controlling the display control circuit (6) and the display illumination light source (11) in an image display mode.

2. An image input device-integrated type display device as claimed in Claim 1, wherein

phase transition type liquid crystals (21) having a storage function are used as the liquid crystals (21).

3. An image input device-integrated type display device as claimed in Claim 1, wherein

n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals having a storage function are used as the liquid crystals (21).

4. An image input device-integrated type display device comprising:

a display unit (1) having a plurality of transparent segment electrodes (X) arranged in parallel with each other on a transparent substrate (29); a plurality of transparent common electrodes (Y) arranged in parallel with each other on another transparent substrate (28), said common electrodes (Y) being perpendicular to said segment electrodes (X), a photoconductor (22) electrically connected to either the segment electrode (X) or the common electrode (Y) and arranged in a pixel composed of an area of intersection between the segment electrode (X) and the common electrode (Y), a transparent island electrode (23) electrically connected to the photoconductor (22) and arranged in between the segment electrode (X) and the common electrode (Y) relevant to the pixel, liquid crystals (51) interposed between the island electrode (23) and an electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), and a polarizer (52) for controlling a polarization direction of only light applying on a side of the electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), said light being to able to reach the photoconductor (22) when the light passed through the polarizer (52);

a display illumination light source (11) which radiates display illumination light in displaying an image on a pixel matrix composed of areas of intersections between the plural segment electrodes (X) and the plural common electrodes (Y) of the display unit (1);

a document illumination light source (11) which radiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit (1);

a control light source (11) which radiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals (51) of the display unit (1);

a display control circuit (6) which generates a display signal for displaying an image on the pixel matrix of the display unit (1);

an image input control circuit (8) which generates an image input signal for copying an optical image of the document into the pixel matrix of the display unit (1);

an image read control circuit (7) which generates an image read signal for reading image data written in the liquid crystals (51) of each pixel constituting the pixel matrix of the display unit (1) in the form of an electric signal;

a segment electrode driving circuit (3) which drives the segment electrode (X) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from the image read control circuit (7);

a common electrode driving circuit (2) which drives the common electrode (Y) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from the image read control circuit (7);

an image data detection circuit (9) which detects the image data written in the pixel matrix of the display unit (1) in the form of an electric signal; and

a control circuit (13) which copies the optical image of the document into the pixel matrix by controlling the image input control circuit (8), the document illumination light source (11), and the control light source (11) in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit (7), the image data detection circuit (9), and the control light source (11) in an image read mode, and displays

en Imege on the pixel metrix by controlling the displey control circuit (6) end the display illumination light source (11) in an Image display mode.

5. An Imege input device-integrated type displey device as cleimed in Cleim 4, wherein
ferroelectric liquid crystals (51) are used as the liquid crystals (51).

6. An Imege Input device-Integrated type displey device as claimed in Cleim 5, wherein
the imege deta detection circuit (9) detects a quantity of electric cherges cherged according to the imege deta et the islend electrode (23) of each pixel constituting the pixel metrix of the displey unit (1),
the control light source (11) can irradiete light one by one on each electrode which is one of the segment electrode (X) end the common electrode (Y) end is not electrically connected to the photoconductor (22), end
the control circuit (13) reads the Image data written in pixel matrix in the form of an electric signel by detecting e quentity of electric cherges charged at the island electrode (23) of the pixel relevent to the one segment electrode (X) or common electrode (Y) which is selected by being irradieted by light of the control light source (11) in the imege reed mode.

7. An image input device-integreted type displey device as claimed in Cleim 1, further comprising en input pen (10) which has e light source (41) end emits light from the light source (41) outwerdly through its tip end, end wherein
the control circuit (13) controls the Image input control circuit (8) end the control light source (11) in e pen input mode to ellow en imege Input by means of the input pen (10) to be written into the pixel matrix.

8. An image input device-integrated type displey device es cleimed in Cleim 4, further comprising en input pen (10) which hes e light source (41) end emits light from the light source (41) outwerdly through its tip end, end wherein
the control circuit (13) controls the Imege Input control circuit (8) and the control light source (41) in a pen input mode to allow en image input by meens of the input pen (10) to be written into the pixel matrix.

9. An Image input device-integrated type displey device es cleimed in Cleim 1, wherein
one of the two transperent substretes (28, 29) of the displey unit (1) is provided with e micro lens (27) for condensing incident light thereto.

10. An Image Input device-integrated type displey device es cleimed in Cleim 4, wherein
one of the two transperent substrates (28, 29) of the displey unit (1) is provided with e micro lens (27) for condensing incident light thereto.

11. An Imege Input device-integrated type displey device as cleimed in Cleim 1, wherein
et least one of the two transperent substrates (28, 29) of the display unit (1) is comprised of e plete-sheped optical fiber array (61) where optical fibers (62) each heving e specified length ere arranged two-dimensionally with axiel directions of the optical fibers (62) extended in e thickness direction of the optical fiber erray (61).

12. An imege input device-integrated type displey device es cleimed in Cleim 4, wherein
et leest one of the two transperent substrates (28, 29) of the displey unit (1) is comprised of e plete-shaped optical fiber erray (61) where optical fibers (62) eech heving a specified length ere arranged two-dimensionally with axial directions of the optical fibers (62) extended in e thickness direction of the optical fiber erray (61).

13. An image input device-integrated type displey device as cleimed in Cleim 1, wherein
the display illumination light source (11), the document illumination light source, end the control light source ere comprised of one plete-sheped light source (11), end e side portion of the plete-shaped light source (11) is pivotally mounted to e side portion of the display unit (1).

14. An Image input device-integrated type displey device as cleimed in Cleim 4, wherein
the display illumination light source, the document illuminetion light source, and the control light source ere comprised of one plete-shaped light source (11), end e side portion of the plete-sheped light source (11) is pivotally mounted to e side portion of the displey unit (1).

15. A device which is selectively operable in a first mode for imege input by light illuminetion, and e second mode for imege display by the application of electrical signals, the device comprising:
e first set of parallel elongete transparent electrodes;
a second set of parallel elongate transparent electrodes speced from end extending transverse to the electrodes of seld first set to define en erray of pixel erees et their crossing points;
e corresponding array of transparent islend electrodes which are electrically unconnected to each other end are disposed et the respective pixel areas between the first end second

sets of elongate electrodes;

a corresponding array of photoconductive elements interconnecting the respective island electrodes and the electrodes of said first set, so that each line of said photoconductive elements connects a corresponding line of island electrodes to a respective said electrode of the first set;

a display medium disposed between said island electrodes and the second set of elongate electrodes;

means operable in the second mode to illuminate all of the photoconductive elements so that display control signals applied to the first elongate electrodes are applied to the island electrodes; and

means operable in the first mode to apply a predetermined image input voltage to said first electrodes, and to selectively illuminate the photoconductive elements so as to cause said image input voltage to be applied to imagewise selected island electrodes.

Fig. 1

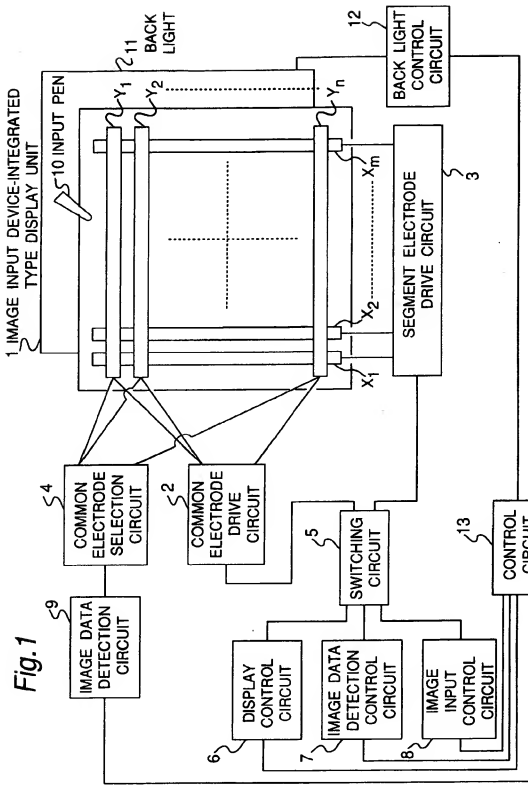


Fig.2

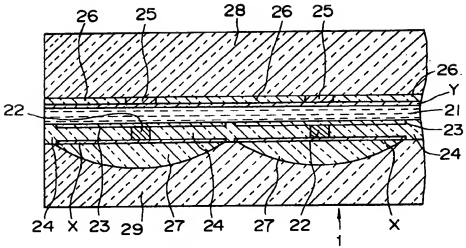


Fig.3

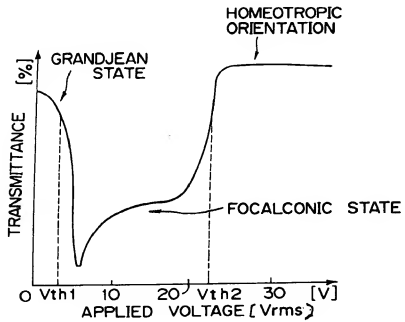


Fig.4

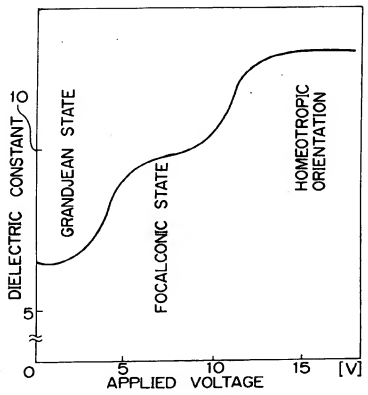


Fig.5(a)

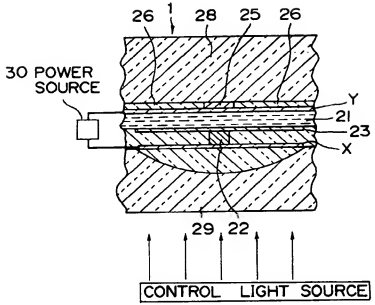


Fig.5(b)

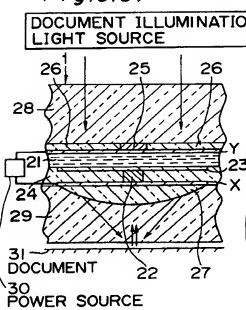


Fig.5(c)

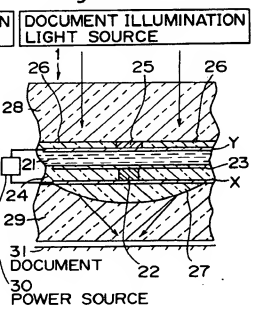


Fig.6

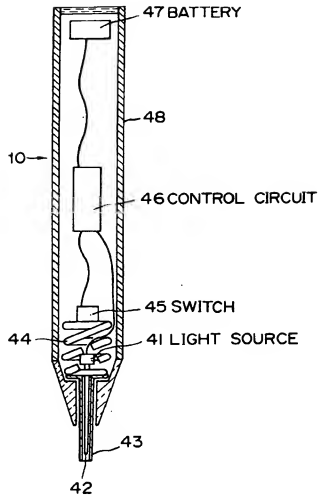


Fig.7

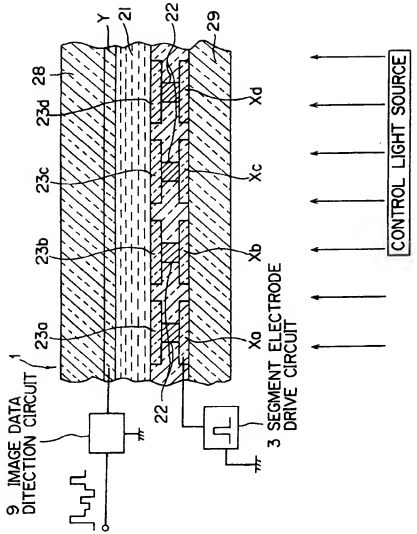
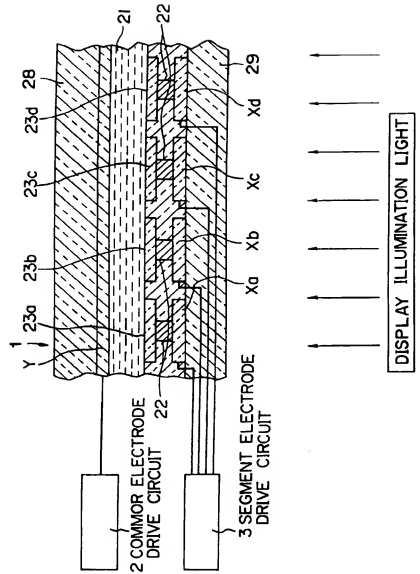


Fig.8



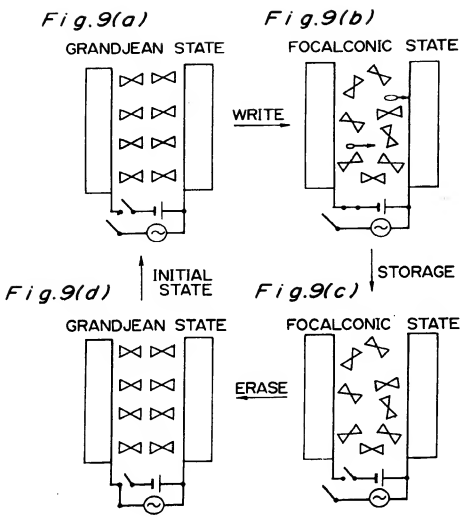


Fig.10

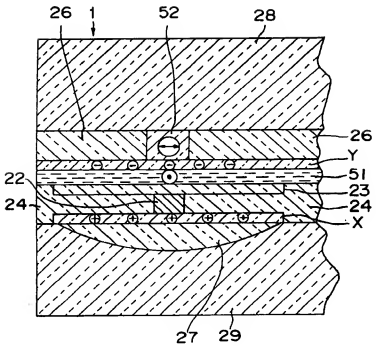


Fig.11(a)

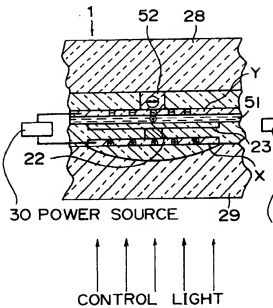


Fig.11(b)

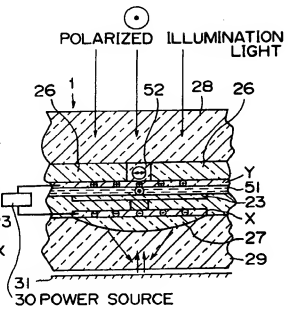


Fig.11(c)

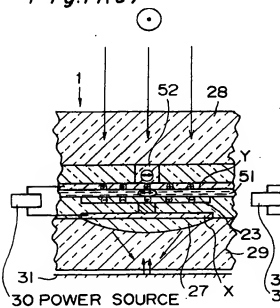


Fig.11(d)

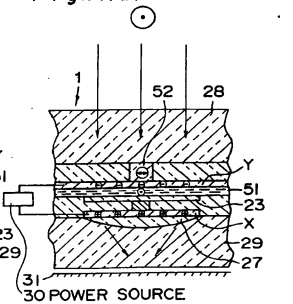


Fig.12(a)

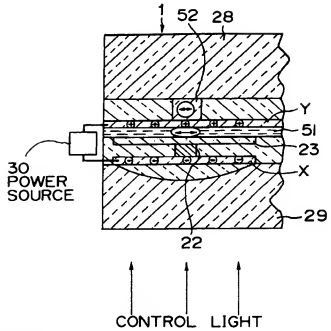


Fig.12(b)

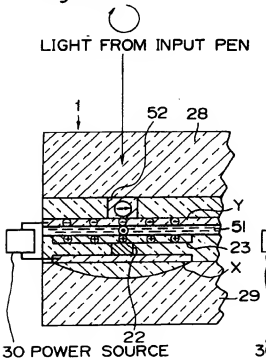


Fig.12(c)

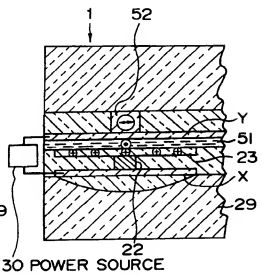


Fig.13(a)

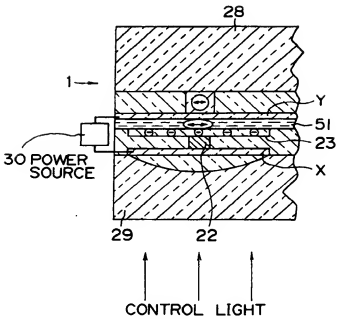


Fig.13(b)

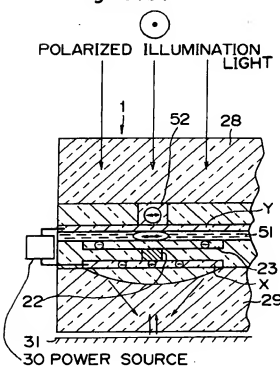


Fig.13(c)

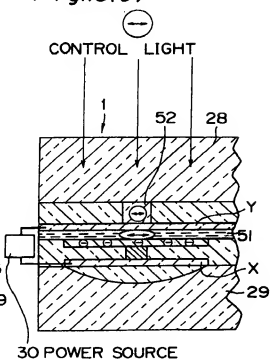


Fig.14(a)

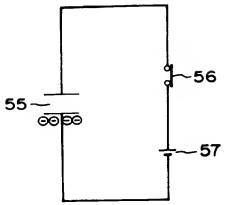


Fig.14(b)

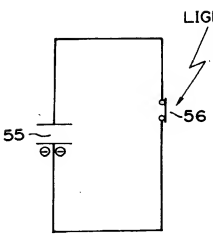


Fig.14(c)

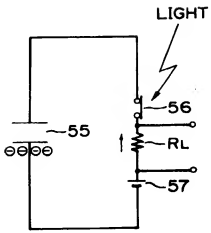


Fig.15(a)

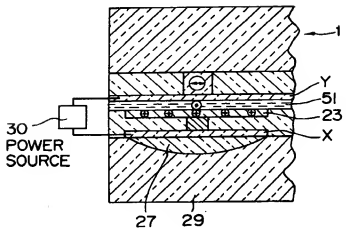


Fig.15(b)

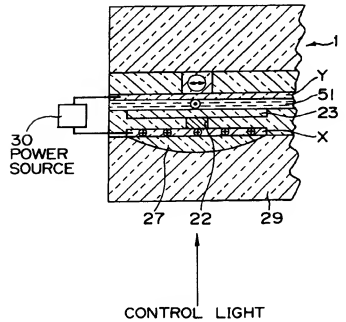


Fig.16(a)

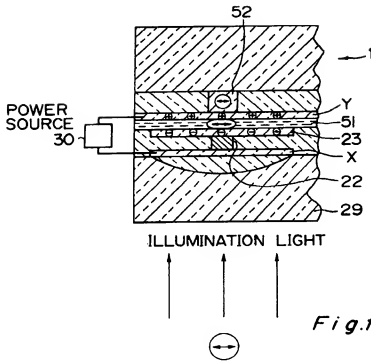


Fig.16(b)

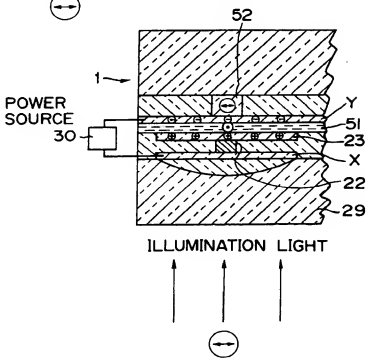


Fig.17

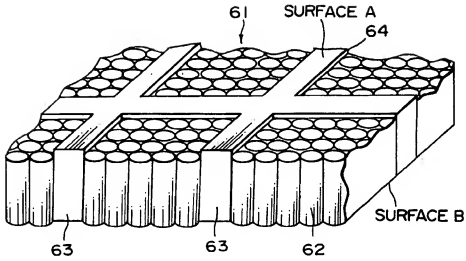


Fig.18(a)

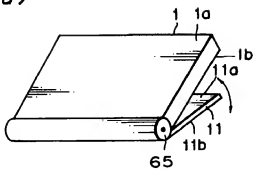


Fig.18(b)

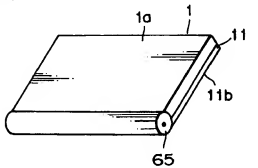


Fig.18(c)